F. W. Hutton, F.R.S.

Trans.] [*Frontispiece.*

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1905

VOL. XXXVIII

(Twenty-first of New Series)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

A. HAMILTON

Issued June, 1906

WELLINGTON
JOHN MACKAY, GOVERNMENT PRINTING OFFICE
KEGAN, PAUL, TRENCH, TRÜBNER, & CO., PATERNOSTER HOUSE, CHARING CROSS ROAD, LONDON

IN MEMORIAM.

Captain F. W. Hutton, F.R.S. (1836–1905).—Captain F. W. Hutton, who was President of the New Zealand Institute at the time of his death, was born in Lincolnshire in November, 1836, and received his earlier education at Southwell Grammar School and at the Royal Naval Academy at Gosport. After serving for some time as a midshipman he left the sea and studied at King's College, London. Soon, however, he received a commission in the Royal Welsh Fusiliers, and saw active service in the Crimea and in the Indian Mutiny.

He had already devoted some attention to geology, and on his return to London in 1860 he was elected a Fellow of the Geological Society of London, and during the next few years gained further practical knowledge of this science by accompanying the officers of the Geological Survey, and in 1862 he published a paper on "The Use of Geology to Military Officers."

In 1866 he resigned his commission in the army, and came to New Zealand and settled for a time in the Waikato district. Before long he was appointed to the Geological Survey Department, and commenced his geological work in New Zealand by making a geological survey of the Lower Waikato district, and this was soon followed by reports of the geology of other parts of Auckland. In 1871, on his appointment as Assistant Geologist, he removed to Wellington, and resided there for nearly three years, when he was appointed Provincial Geologist of Otago, and took up his residence in Dunedin. Here he continued his geological work and published a geological map of Otago, and, in connection with the late Professor Ulrich, brought out a work on the geology of Otago.

He had already commenced work also at the zoology of New Zealand, where the labours of a systematist were greatly needed, and in 1871 had published a catalogue with specific diagnoses of the birds of New Zealand. This was soon followed by a catalogue of the fishes, and papers on the bats and lizards, and in 1873 his catalogue on the marine *Mollusca* appeared, thus laying the foundation for the large amount of work which he afterwards did on the New Zealand *Mollusca*.

In 1876 he was appointed Professor of Natural Science at Otago University, and had charge of the Otago Museum, which indeed he may be said to have founded, for the building was designed and all the internal arrangements fitted up under his direction, and a large part of the natural-history specimens were brought together by his exertions.

About four years later he was appointed Professor of Biology at Canterbury College, and about the time of his removal to Christchurch he published a little work, "Zoological Exercises," in which he adapted the method of instruction in natural science by Huxley to the special requirements of New Zealand students. In Christchurch he continued to publish papers on various branches of New Zealand zoology, but these were varied with others on various geological questions, and for some time, owing to the wants of his students, he devoted considerable attention to botany. Later on he had temporary charge of the Canterbury Museum after the death of Sir Julius von Haast, and in 1893 he succeeded Mr. H. O. Forbes as Curator, and acted also as lecturer on geology—for this purpose resigning the professorship of biology.

About three years ago, feeling the strain of lecturing too much for him, he gave up his lectureship, but continued as Curator of the Museum. In March, 1905, he left for England on leave of absence, but almost immediately after his arrival there he had a second attack of the severe illness from which he had suffered about two years before, and though he recovered to some extent he did not survive to reach New Zealand, but died during the return voyage.

Captain Hutton naturally took a large share in the work of the various scientific societies of New Zealand and Australia. He was successively a member of the Institutes at Auckland, Wellington, Dunedin, and Christchurch, and served several times as Secretary, Treasurer, or President in the two last named. He was also an honorary member of the Linnæan Society of New South Wales, Fellow of the Zoological and Geological Societies, and member and President of the Australasian Ornithological Union. In the Australasian Association for the Advancement of Science he served as General Secretary for the Christchurch meeting in 1891, President of Section C (Geology) in 1890 and 1898, and President of the Association at the Hobart meeting in 1902. He was elected a Fellow of the Royal Society of London in 1892, and in 1904, after the reconstitution of the New Zealand Institute, he was unanimously elected its first President.

Of Captain Hutton's work on the geology and zoology of New Zealand some mention has been already made. Naturally a great part of his time was devoted to systematic work, and many papers dealing with practically all classes of animals will be found in the "Transactions of the New Zealand Institute," and in the scientific journals of Australia and Europe. To the birds he devoted special attention, and his important paper on the "Moas of New Zealand" (Trans. N.Z. Inst., vol. xxiv) requires special mention. He also gave much time to the study of the *Mollusca*, and in addition to many papers in the Transactions published several catalogues of them, the most important of them being his "Manual of the New Zealand *Mollusca*," issued separately in 1880, and in the same way he catalogued many of the different groups of insects. His systematic work was summed up and brought so far as possible to a conclusion in the "Index Faunæ Novæ-Zealandiæ," edited by him and published by the Philosophical Institute of Canterbury in 1904, and a glance through its pages will show how large a number of the animals recorded from New Zealand have been named and described by him. Two more popular works written in conjunction with Mr. James Drummond deserve mention—viz., "Nature in New Zealand" and "The Animals of New Zealand," the latter being a beautifully illustrated account of the air-breathing vertebrates of New Zealand.

But Captain Hutton was far more than a systematist, and as far back as 1873 he dealt with the origin of the fauna and flora of New Zealand in a paper "On the Geographical Relations of the New Zealand Fauna" (Trans. N.Z. Inst., v, p. 227), and he returned to the subject again in 1884 and 1885, and a concise and judicial summing-up of our knowledge of the subject will be found in the introduction to the "Index Faunæ Novæ-Zealandiæ." Of the various explanations offered by him to account for some of the difficult questions in connection with this subject it is not necessary to speak here in detail—they are well known to all students of the subject, and have long since established Captain Hutton as a leading authority on the distribution of animals and plants.

During the whole course of his career Captain Hutton gave much thought to the fundamental questions of biology. In 1861 he wrote a review of Darwin's "Origin of Species" for the "Geologist," which showed that even thus early he had grasped and accepted the fundamental principles of the theory of descent, and he continued to deal with various aspects of the question in numerous addresses and lectures. In 1899 he published his "Darwinism and Lamarckism, Old and New": and in 1902 appeared "The Lesson of Evolution," containing his Presidential Address to the Hobart meeting of the Australasian Association for the Advancement of Science, and other essays.

In addition to the large amount of work that he personally performed, Captain Hutton greatly aided and advanced our knowledge of the natural history of New Zealand by the advice, stimulus, and assistance which he at all times so willingly gave to younger workers, and his name will always remain inseparably connected with the foundation of New Zealand geology and zoology.

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Portrait of the late Captain Hutton.

NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867"; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER "THE NEW ZEALAND INSTITUTE ACT, 1903."

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A. HAMILTON,
Editor.

TRANSACTIONS

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OF THE

NEW ZEALAND INSTITUTE,

1905.

Art. I.—*Early Native Records of the Manawatu Block.*

By P. E. Baldwin.

[*Read before the Manawatu Philosophical Society, 23rd February, 1905.*]

The records we have in connection with the Maori occupation and settlement of the place where we now live, and the immediately surrounding country, are exceedingly meagre. The reason is obvious to any person who has had any considerable experience in the ways of the ancient Maori. As we are all aware, the whole of this country, with very limited exceptions, was originally bush-covered, and, if we except one or two tracks, was not crossed by any highway. Moreover, these tracks were by-paths — they did not form a recognised communication between densely populated parts of the country. Land so circumstanced—bush-covered and pathless—has never loomed large in the history of the Maori people. Before the advent of the European the bush-covered lands were only of value to the Maoris, and were only utilised by them, as places of food-supply and game-preserves. And even in this connection the valued area was limited. The native game of the country, especially the wood-pigeon and the kaka, usually restricted themselves to certain more or less well-defined spaces, while berries grow mostly on the outskirts, rarely in the centre, of the forest; so that to the old-time Maori bush country in general formed a possession of little value, except in so far as the streams running through it held eels.

For, as far as the Native Land Court records run, the Natives always proved the title of their tribe to the mana over certain land by matters relating to the feeding of the tribespeople. Eel-weirs, places for snaring birds or steeping berries, actual cultivations—these alone were matters of moment to the old Maori.

It is on these that stress is laid in asserting title. To the Native an easy and comfortable supply of food was of the utmost moment, and old-time difficulties in obtaining it moulded deep into his character another trait—jealousy of other tribes, especially in matters pertaining to the occupation of lands. The Maori brooked—so far as he could sustain his possession—no interference with his feeding-places. Defined landmarks were always set, and were considered true boundaries between the lands of adjoining tribes.

Similarly the hapus had their well-marked spheres of influence, and, in the vast majority of cases, special defined areas of the land under the ægis of their particular Native tribe. But both the boundaries and the area had relation to feeding-facilities, and heavy bush country for that reason did not lend itself to marked dispute except incidentally. So it was with the greater extent of the Manawatu Block.

But, passing to a consideration of the large block forming the countryside around, the prospect clears, and we get more definite detail.

Dealing generally with the land between the Rangitikei and the Manawatu Rivers, we find, when history dawns, early in the last century, that the whole of the country was occupied by branches of the Rangitane Tribe, which had fought its way from the East Cape, and by their allied tribes, the Ngatiapa and Muaupoko. As between themselves the Muaupoko held the southern portions, the Ngatiapa the northern, while in the centre were the Rangitane. The main habitations in the Manawatu district were those of this latter tribe along the banks of the Oroua and Manawatu Rivers, where food was plentiful. Here they had populous settlements and large pas. The tribes were numbered in hundreds—in one expedition twelve hundred took part—and they lived then secure and prosperous in the open and fertile country.

The bush and mountain pas came later, and formed, as is usual with Natives, the brand of troublous times. Early in the century, at a date placed variously from 1818 to 1827, the Ngatiapa were first disturbed in their possession by the Ngatitoa war expedition of Rauparaha and Waka Nene, which is so well remembered. This war-party fought its way down the coast, defeating and grievously crushing the Ngatiapa, the Muaupoko, and, in part at least, the Rangitane; for although the Rangitane have in latter days expressed ignorance of the raid except in so far as Rauparaha came into conflict with them at Hotuiti, the contention savours of absurdity. If the Rangitane did firmly hold the land then, the two parties—on the one hand the intruders and on the other the occupants—could not have failed to come into conflict. However, be that as it may, the northern war-party returned home after dealing some shrewd blows to the Manawatu tribes, and Rauparaha in the following years made preparations for his great *heke* or exodus from Kawhia to this district, in which he was accompanied by the Raukawa and a section of the Ngatiawa. The history of his return spelt ruin to the Manawatu Natives. Having fought his way south to Kapiti, he established there his headquarters, having at his call the three tribes who composed the migration—viz., the Ngatitoa, the Ngatiraukawa, and a portion of the Ngatiawa. The power of his war-parties, his rifles, his own ability and ruthlessness, and the weakness of the original inhabitants, all tended in one direction—the complete subjugation of the old residents, and the establishing of the new tribes' mana as far north as the Wangaehu River, as far south as Wellington. Moreover, a treacherous murder of Rauparaha's children by the enemy lent the war from his side a ruthlessness exceeding the ordinary tribal conflicts. Slaughtering, harrying, massacring wherever occasion allowed, Rauparaha decimated the district, and drove into hiding the shattered tribes from the Wangaehu to Port Nicholson.

The scene of this murder, so fatal to the tribes concerned, was Papaitonga, situated in the beautiful lake where Sir Walter Buller now lives. The place is one of the masterpieces of nature. A small island rises in the lake, bush-clad to the water's edge; the ferns, nikau, kowhai, and other native trees are reflected in the perfect mirror of the lake. Here was the pa of Toheriri, a leader of the Muaupoko, and here Rauparaha was invited to a friendly visit, the bait held out being the promise of some war-canoes. Rauparaha went with his wives, his children, and a handful of followers, and in the darkness the entire party except Rauparaha and a little girl were murdered. The great chief escaped, and swore a signal revenge. He swore to kill Muaupoko and Ngatiapa from early morn till dewy eve; and well he kept his word. He hunted them on land, he hunted them in the mountains, he followed them to their lake fortresses. To take Waiputa, a fortification in the Horo lake, his men swam off; to take the great Papaitonga Pa of Waikiekie they dragged their canoes overland. In each case the same fate befell the defenders. They were cut down to a man, woman, or child, and the lovely little island at Papaitonga still hides legions of dead men's bones. This was the fate of Muaupoko. Nor did Rangitane and Ngatiapa fare much better. Rauparaha harried them with his Ngatitoa, and the war-parties of Ngatiwaewae, Ngatipikiaha, and Ngatimaniapoto—hapus of the Raukawa—spread over their lands from the Oroua to Rangitikei as far north as Kakariki. At Kakariki, Awahuri, Tuwhakahepua, Puketotara—

wherever these people congregated they were attacked, dispersed, and massacred until not one place of any importance was left them as a fortress, and the wretched remnant of these once important tribes was a number of frightened fugitives furtively living so long only as they could escape their foe's notice. So severely were the tribes dealt with that, even counting Ngatiraukawa, a Government censor in 1860 estimated the total Native population of the Manawatu at six hundred persons. The conquered territory was parcelled out. Ngatiawa had the south, Ngatitoa the centre, while the northern portion, including the Rangitikei and Manawatu, was allotted to the Ngatiraukawa. To use the words of an old Native,—

"30th April, 1866.

"To Captain Russell, Native Minister.

"What we have said is true—neither Ngatiawa, Rangitane, nor Muaupoko have anything to do with it [the land]. The truth is, on our arrival they were all killed or beaten by Te Rauparaha. The mana of the land had also departed, and they remained slaves. Again, Te Rauparaha was continually slaying the people who had murdered his children. On account of our long residence at last Rauparaha ceased slaying them, and then they lived. The word of Rauparaha went forth, Let the land remain for Raukaroa as far as Rangitikei, as far as Otaki. By this time we obtained authority over these lands, and by this our withholding the land is just. Again, we have been living on it for many years. We have lived on the land thirty-one years. The fire of Ngatiapa has not been kindled up to the present day. This is why our speech has been put forth — first Governor Grey, second Governor Browne, third Governor Grey again. Our determination to hold fast the land is fixed and will never cease."

Now, were the Ngatiraukawa justified from a Native point of view in this claim? In order to be in a position to fairly estimate this, certain salient features should be borne in mind, which it seems to me have been lost sight of by most of those who have given the matter impartial consideration. One cardinal factor dominates any theory on the subject — a factor entirely opposed to our common views of titles to land. We must eliminate from the discussion all question or idea as to who owned the land. Maoris knew no ownership in land. No individual owned land, no hapu owned land, no tribe owned land. Over certain very limited areas individuals possessed certain usufructuary rights — in certain game-places, cultivations, and eel-weirs families or hapus might have a joint right, excluding to some extent the rest of the tribe—while the aggregate of these rights of enjoy-ment, backed—and only so long as it was backed—by the mana of the tribe, formed the so-called Native ownership. Ownership it was not. The power to prevent others from exercising rights, and that this power was recognised by those others—this, in a word, constituted the "mana." The actual exercise of the rights was not necessary. Interference with the rights might occur and not destroy them. So long as the recognised ability to permanently exercise the rights, and the correlative ability to stop others, obtained, so long did the tribe having that ability have the mana. But, co-existing with the mana of one tribe over the whole land within settled tribal boundaries, portions of another tribe might in one way or another have limited rights over certain defined parts. Such rights would be confined to the actual usufruct enjoyed, and would not give mana over the surrounding country. It might be a settled and long-standing concession, strictly limited. This in process of time became practically irrevocable, and one method alone extinguished the limited rights that the exercise of such privileges gave to any nomad or wild tribe upon any specific territory: that method was death. Death alone completely extinguished the rights and left no flaws on the title. This it is that points the grim wit of Mr. T. C. Williams's description of Te Rauparaha as "the ablest conveyancer of the period." His title-deeds were without flaw. And the old Maori urged this on his tribes, "Clear the weeds from my garden." Unfortunately for them they did not.

Now, as we have seen, the northern part of the territorial conquest passed to the Raukawa. Extended as they were far away from the influence of Rauparaha and his ruthless savagery, as time passed along they dealt gently with the broken tribes. "The rain from heaven might fall on these tribes," to use Whatanui's descriptive phrase, "but no man's hand should be on them." So it was with the Muaupoko, and so it was with the Rangitane, and the beggarly fragment of Ngatiapa that unobtrusively crept from their bush hiding-places. The Raukawa, magnanimous in their victory, allowed these wretched people a settlement, allowed them to occupy, allowed them to cultivate. But the mana to the Wangaehu was with the conquerors. No tribe would have dared occupy the country hostilely to them. It was under the Raukawa mana that the Ngatiapa and Rangitane rested alive and unharried.

So it was when the Europeans commenced to push their way, and abundant testimony proves it.

But the coming of the white man spelt fresh trouble. Among the older settlers Mr. F. Robinson took up a block of some 20,000 acres near Foxton, Mr. Thomas Cook a similar area in the same district, Mr. Steven Hartley a small piece on the Manawatu

River; Mr. Bull and Mr. Donald Fraser each took a large block in the Rangitikei district; Captain Earl—or, as he is called in the records, "Kerl"—and Mr. Daniels also took up large holdings in the Rangitikei. Each of the northern settlers obtained his holding by the consent of the Raukawa Natives who lived in the immediate vicinity of the land leased. These lands were held on various terms, at various rentals, but it appears that the whole of the rents were paid to, and the leases were made by, a chief of the Raukawa called Nepia Taratoa. And it was only as this old chief felt the touch of Death on his shoulder that he parcelled out portions of the rents to Ngatiapa and a portion to Rangitane. Nepia was the moving and managing spirit in the leasing, as in the consent to the sale of the Rangitikei Block by the Ngatiapa, and the Upper Manawatu or Ahuahirangi Block by Rangitane. The fact that the consent was sought for and given further strengthens the Raukawa claims.

It must not, however, be assumed that the Rangitane in particular were entirely crushed, at any rate until long after 1830. The name of the tribe, perhaps the most warlike of the three, appears in connection with blocks situated far away from the Manawatu district. This was exemplified to me in a somewhat startling way at the hearing of the Tipapakuku Block. Mr. Southey Baker was cross-examining one of the claimants as to whether he was one of the Ngatipakapaka. The man questioned, Ihaia te Ngar ra, flew into a violent passion and shouted out, "Yes, I am a Ngatipakapaka, and I will tell you why I am called a Ngatipakapaka. When I was a boy, my father and my uncle and I were hunting a sort of a short-tailed dog, which had been recently introduced, and which we kept as pets. Hoani" [pointing to Hoani Meihana, who sat a little bit away, champing his toothless gums] "and his war-party came across the mountains, and they caught us, and they killed us, and cooked us, and overcooked us, and that is why I am called Ngatipakapaka." In the case in question Meihana was allowed in as an equal fifth owner in this block, which was situated beyond Dannevirke.

To return, however, to the Manawatu-Rangitikei. It is indisputable that by the clemency of their victors portions of the three tribes returned to inhabit without let or hindrance limited areas in the block, and, as the power of the Government gradually strengthened in the years following 1840, the Ngatiapa, and to a certain extent the Rangitane, who had really been living by the sufferance of the Raukawa, commenced to arrogate to themselves the position of owners of the land they were occupying. The Muaupoko claim came later. In all cases where through the clemency of the conqueror the original inhabitants had been allowed even a precarious holding, they, as soon as the reign of law arose, stretched their claim to that of an undisputed possession of their lands. The three sections of Raukawa which established themselves in the Rangitikei-Manawatu, and Whatanui's branch, which occupied the land about Horowhenua, made a mistake from a territorial point of view when they left the original inhabitants to maintain a precarious existence, for European ideas and European interference pushed the matter eventually to a pitch of injustice. The claims of the subject tribes through the years following gradually strengthened. The fighting with the rebels gave them a further claim. Armed by the Government with rifles, and supplied with ammunition, the Ngatiapa assumed an arrogant attitude, until at last the whole matter came to a head in the year 1863. In the year 1862—not 1865, as Buick, generally so accurate, states—the first Native Land Court Act was passed, and Courts were set up to ascertain and determine the tribal ownership of the lands. As it was pointed out at the time, this Act, despite many flaws and many weaknesses of detail, was a step in the right direction, as it enabled the ownership or crystallized mana of the land to be definitely determined before the memory of the truth had passed away. To the great disgust of the Manawatu Natives, however, the Rangitikei-Manawatu Block, and the Raukawa blocks on the West Coast, were expressly excluded from the operation of the Act, and a feeling of anger and alarm was thus raised in the ever-suspicious minds of the tribes concerned. At the time in question the King movement was very pronounced throughout the whole of the land; and a Commissioner, who made a tour throughout the whole of the land, and in, amongst others, the Manawatu district, reported that at Otaki, at Poroutawhao, and other settlements, including the Rangitane cultivations on the Oroua River, the King party was in a strong majority. Trouble began to brew, the only element wanted being a leader. This leader was soon forthcoming in Ihakara Tukemaru, a Ngatiraukawa chief, who had his residences at Motuiti and Kereru. It was represented to the Raukawa that the reason their land was excluded was because the Ngatiapa Tribe was selling to the Government, and were claiming the whole of the block lying between the Rangitikei River and the Manawatu. The discontent grew apace, and was fostered by Ihakara, so that it finally culminated in preparations for a fight. The Ngatiraukawa, under Ihakara, together with the Rangitane, collected at Tawharitoa, Ihakara's pa, to the number of some four hundred. The Ngatiapa, who were in a large minority, appealed to the Wanganui tribes, who thereupon expressed their intention to support them, and they, too, commenced to construct a fortified pa on the other bank of the Rangitikei River at Owharoa, close to where Bull's now stands. Here they hoisted the Union Jack and a small red war-flag.

Dr. Featherston, the then Superintendent of the Wellington Province, received information of the pending fight, and forthwith proceeded with Mr. (now Sir) Walter Buller to the scene of the dispute. According to his own account he found affairs at a pitch of high tension. Just before his arrival the Ngatiraukawa had danced a war-dance, which was tantamount to a declaration of war. He first proceeded to their pa, and had a long interview with the chiefs. He pointed out that the Government would severely suppress any hostilities, and would treat as murder any bloodshed that took place during their fight. He promised to see the Ngatiapa, and suggested that arbitration should be resorted to to determine the ownership of the lands in dispute. To this the Ngatiraukawas declined to accede. "*Kahore*," said Ihakara; "the arbitrators must meet in the presence of the three tribes. The tribes will meet with their arms in their hands. Each man will say what he pleases." They had found that arbitration in the past had not proved a satisfactory method of settling disputes as to the ownership of land, and they firmly declined to have anything to do with any such proceeding, except in the way suggested. Dr. Featherston then suggested as an alternative that the land should go through the Native Land Court, or that a division should be made by a Government valuer of the land; but this course was even less satisfactory as a proposition than the previous one. This is not to be wondered at, inasmuch as Dr. Featherston suggested every difficulty that the course would necessarily imply. Matters thus having come to a deadlock, a suggestion was made which I feel sure was the original suggestion that Dr. Featherston had in his mind. I refer to the suggestion that the parties should sell the block to the Government, and that, instead of fighting about the land, they should divide the money in proper proportions. To this the Raukawa declined altogether to consent. Dr. Featherston then, having reiterated his warning, went to the opposite camp and interviewed the Ngatiapa. He put forward to them, in a half-hearted way, the first two propositions he had made to the Raukawa, but they firmly declined. When, however, he approached the sale of the land the Ngatiapa consented; and this, I think, confirms the theory which has been held by most people, that the Ngatiapa had no real claim in the land. They sold to make good their title—just as Solomon's spurious mother consented to the child's death. Dr. Featherston, however, pointed out that he would not buy the land from them alone. He did not wish to have any more Waitara Blocks. He was, he said, prepared to purchase their interest in the land.

This they at first declined, and matters looked as unpromising as before. Eventually, however, as the result of considerable exertions, Dr. Featherston arranged with the more active chiefs of both parties that the Government should give them the sum of £25,000, and that the money should be subsequently divided as a tribunal to be appointed should consider fair. The consent of the tribe, which Ihakara pointed out was essential, and the signature of the deed, was left for another time. The three tribes having, however, consented so far, it was felt that hostilities were averted, so by consent all rents were impounded, and Dr. Featherston returned to Wellington.

During his absence, however, and before the deed was actually signed, steps, and very active steps, were taken to embroil the whole matter again. A cartoon was the most effective weapon used. To quote Ihakara, "The tribe sent a petition to have the land investigated in the Court. The Assembly refused—Kaiongi told me, on account of Buller and Featherston. I replied to Kaiongi's letter, and in return received a caricature representing the three tribes as pigs with Maori heads being led and driven by Featherston and Buller." The Natives were also informed that Dr. Featherston and Mr. Buller had been instrumental in putting a fence round their lands to fence it off from the benefit of the Native Land Act. The ever-ready suspicions of the Native mind sprang up. Each tribe demurred, and so incensed in particular were the Raukawa that they promptly repudiated the whole deal between them and the Government. The position was, to a certain extent, conduced to by Mr. Mantell, the then Colonial Secretary, who, in addition to flouting the Maoris in every way possible, and discounting the work which had been done, removed and apparently degraded both Mr. Buller, who had been very active in effecting the settlement, and the then Resident Magistrate, Mr. Noake.

Dr. Featherston, however, with characteristic energy, was not to be thwarted in his attempt to acquire for the Government such a valuable asset as the Manawatu Block, and he accordingly called together a very large meeting of the Natives, and again addressed them on the subject. The meeting took place at Scott's Ferry, and was very largely attended by the Raukawa Tribe. Dr. Featherston first listened to their grievances. They dwelt bitterly upon their being represented as pigs, also upon the way they considered they had been flouted and betrayed by Dr. Featherston, and still more on the exclusion of their lands from the provisions of the Act. His reply was on the same lines. He pointed out that if they were compared to pigs, he, on his part, and Mr. Buller, might be compared to sheep driven away by the tribes off the land; that the fact that any one should cartoon him in that character would not affect the attitude he had taken up, even if it should also be pointed out what a bad bargain he had made with the tribes. He replied in detail to the whole of the charges which had been levied against him; and, partly through the influence of Mr. Buller and partly through a promise to allow the Act to operate over the other lands of Raukawa, succeeded in reducing the tribes again to a state of satisfaction, with the ultimate result that the purchase was eventually allowed and ratified by the whole of the tribe with certain exceptions.

I cannot help thinking that here, as so often happens in Native matters, the most active sellers were those with the least personal estate. This was so even with the Raukawa, and the dignified lament of Parakaia te Pouopa breathes the spirit of truth: "Give heed. Thus far have I shown kindness to those tribes who were spared by ourselves from slaughter by Te Rauparaha. Rangitikei, a large block of land, I graciously gave to Ngatiapa; Te Huaturanga, a large block of land, I graciously gave back to Rangitane; and now these tribes together with the Government come openly to take away my piece remaining; outhouses and the cultivations whence my tribe get their living are being taken away."

But the land was sold, and the Native Land Court set up to deal with the division of the money and the allocation of reserves. The judgment was a lengthy and laboured statement, founded upon the evidence of Ngatiapa alone. Summarised, the result was a judicial apology for and vindication of Ngatiapa and Rangitane, and the diversion to them of a large sum justly due to Raukawa if any one. This judgment was followed by the setting-aside of seventy-five reserves, about 24,000 acres in extent, for non-sellers and in part for sellers.

Such is a short and imperfect sketch of the occupation of the Manawatu Block, and the transfer of that block to the Government; and if we apply to it the principles we have laid down, the injustice of the Manawatu-Rangitikei acquisition stands nakedly before us. The Raukawas were the real owners of the block. Instead of receiving, as they did, £10,000, the whole of the purchase-price should have come to them, leaving to the Ngatiapa and Rangitane the limited rights over strictly defined areas which they had acquired by the clemency of their conquerors. This did not suit the Government. In this case, as with Horowhenua—an even more monstrous injustice—their whole object was to prevent trouble. The turbulent party was the undeserving party, but their insistence won the day. A threat of rifles and the Government of the day descended from their lofty attitude and accepted the Native position, prostituting justice and their own Court to secure a convenient verdict. The blot of Rangitikei-Manawatu will always lie on the record of the Native Land Court, only surpasssed by that of the Horowhenua, the judgment in which reads like one of Horace's finest satires. Nor was the Native Land Court consistent; and the deadliest comment on the judgment in the two blocks referred to is furnished by the same Court's judgment in the Manawatu-Kukutauaki cases.

Art. II.—*Magmatic Segregation in its Relation to the Genesis of certain Ore-bodies.*

By Professor James Park, M.A.Inst.M.E., M.A.Inst.M. and M. (Lond.), F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

Ore-deposits are of diverse form and composition. They are found as true veins, as detached masses, and as members of a sedimentary formation. It is now known that their mode of occurrence, and, to some extent, their composition and form, are determined by the prevailing geological conditions.

In the past decade a vast mass of facts has been added to the literature of the subject, particularly in America, where the magnitude of the operations connected with mining has afforded great facilities for observation and research.

The genesis of ore-deposits presents many difficult problems, and naturally the literature of the subject is rich in theoretical deductions. The introduction of petrographical methods of investigation, and the demonstration of the principle of metasomatic replacement, marked a new point of departure, and led to a truer conception of the formation of ore-deposits than had formerly existed.

In this investigation we must remember that existing conditions are but a reflection of the past. The agencies that built up the crust of the earth in its present form are still in operation, and still governed by the same natural laws. We are living on the edge of a geologic epoch, and if we would rightly understand the past we must study the present. The occurrence of ore-deposits is merely a geologic happening—an incident in the tectonic arrangement of the materials forming the outer shell of the globe. Recent petrographical investigation has shown that ore-deposits are always more or less intimately connected with igneous rocks. This constant association naturally leads to the broad generalisation that mineral-deposits are genetically connected with the intrusion or eruption of igneous magmas.

It has been shown by Professor Sandberger and others that igneous rocks contain all the constituents of mineral veins. Professor Vogt, of Christiania, maintains that the belief in a deep-seated inaccessible repository of the heavy metals can no longer be sustained.* Modern geologists, he points out, have abandoned the old conception which supposed that the interior of the earth was an enormously compressed liquid molten mass of high specific gravity charged with heavy metals. The composition of the molten magmas that have issued at the surface in successive geological ages does not favour any hypothesis which assumes the existence of a greater proportion of the heavy metals in the barysphere than in the upper crust, or lithosphere. Referring to the distribution of the elements in the earth's crust, Vogt states that of the entire earth-crust—including the rocks, sea, and atmosphere—oxygen constitutes by weight about one-half, and silicon about one-quarter.† The proportion of the other elements are, he says, as follows:—

	Per Cent.	
Alumina, iron, calcium, magnesium, sodium, and potassium ...	10	to 1
Hydrogen, titanium, carbon, and chlorine	1	to 0·1
Phosphorus, manganese, sulphur, barium, fluorine, nitrogen, zirconium, and strontium	0·1	to 0·01
Nickel, lithium, vanadium, bromine, and perhaps beryllium and boron	0·01	to 0·001
Cobalt, argon, iodine, rubidium, tin, cerium, yttrium, possibly arsenic and others	0·001	to 0·0001

In igneous magmas deficient in acid-forming constituents the heavy metals will segregate as oxides during the process of cooling, assuming the form of individual crystals, grains, or irregular aggregates in small and great masses.

The petrographical researches of Vogt and Brögger disclosed in basic dykes a tendency of the heavy minerals to segregate near the borders. The occurrence of massive mineral aggregates near their borders is a marked characteristic of peridotites and serpentines in all parts of the globe.

The most typical examples of magmatic border segregation are found in peridotite and its serpentinised forms. At pre-

* Professor J. H. L. Vogt, "Problems in the Origin of Ore-deposits," "Genesis of Ore-deposits," 1901, p. 637. (Published by American Institute of Mining Engineers.)

† *Loc. cit.*, p. 639.

sent the laws governing magmatic differentiation are but imperfectly understood. By some border segregation is ascribed to molecular flow due to differences of temperature in the magma; by others to convection currents, which it is believed would tend to carry the first crop of minerals, such as magnetite, olivine, &c., to the borders of the igneous magma.

The writer* is inclined to ascribe border segregation to the difference of osmotic pressure that must exist in a finite mass of magma cooling more rapidly in the borders than in the central portion.

The valuable ores that may be considered primary constituents of eruptive rocks, resulting from direct differentiation in the cooling magma, are as follows:—

(*a.*) Chromite in peridotite and serpentine.
(*b.*) Copper and nickel-iron in serpentine.
(*c.*) Platinum metals in highly basic eruptives.
(*d.*) Magnetite and titanite in basic and semibasic eruptives.

Chromite in Peridotite.

In the South Island of New Zealand there are two mountain-masses of peridotite in which the magmatic segregation of chromite is exhibited on a scale of unusual magnitude.

A few miles from the City of Nelson, Dun Mountain rises to a height of over 4,000 ft. above sea-level. It covers an area of about four square miles, and is entirely composed of massive olivine, in which chromite of iron is fairly uniformly disseminated in the form of fine grains, but is occasionally aggregated in large masses.† The adjacent rocks are slaty shales and limestone of Jurassic age, the limestone occurring at the base of the sedimentary formation. Between the limestone and the olivine, to which Hochstetter‡ gave the distinctive name "dunite," there is a belt of serpentine, half a mile wide. The serpentine contains lenticular-shaped masses of chromite, native copper and copper-ores, principally chalcopyrite, with the usual products of oxidation. It also contains thin irregular veins of diallage, hypersthene, bronzite, enstatite, scapolite, wollastonite, and chrysolite. The larger deposits of chromite occur near the borders of the olivine and serpentine.

The second great mass of peridotite forms Red Mountain, situated twenty miles north of Milford Sound, in Otago.§ It

* J. Park, "On the Cause of Border Segregation in some Igneous Magmas," Trans. N.Z. Inst., vol. xxxvii, 1905.

† S. H. Cox, "Chrome-deposits of Nelson," New Zealand Geol. Reports and Explorations, 1881, p. 8.

‡ Dr. F. von Hochstetter, Zeitschrift der Deutschen Geol. Gessellschaft, vol. xvi, p. 341.

§ J. Park, N.Z. Geol. Reports and Explorations, 1886–87, p. 121.

rises to a height of over 6,000 ft., and covers an area of about ten square miles. The mountain is composed of massive olivine containing disseminated chromite. The latter occurs in much greater proportion than at Dun Mountain. The peridotite is flanked on two sides by belts of serpentine, which separate it from the adjacent slates and sandstones of supposed Palæozoic age. Near the contact with the sedimentary rocks it is often so highly charged with chromite as to form compact bodies of ore. No deposits of chromite are known in the serpentine, but they may possibly exist, as the country is still practically unexplored.

Nickel-iron.

The sands in the streams which drain the Red Mountain serpentine area yield small quantities of the rare nickel-iron alloy awaruite, discovered by Skey in 1885,* and afterwards found *in situ* in the serpentine.†

Since the discovery of awaruite nickel-ore alloys have been found in several places, most notably in gold-bearing sands associated with chromite in Elvo River, Biella, Piedmont, Italy; in sands derived from serpentine in Josephine County, Oregon; in the Fraser River, British Columbia, associated with chromite; and in Smith River, Del Norte County, California.

Copper.

The association of copper and chromite in the serpentines at Dun Mountain has already been mentioned. Native copper is found in serpentine in Cornwall, New South Wales, New Caledonia, and other parts of the world.

Large masses of native copper associated with silver are found in amygdaloidal diabase at Lake Superior.

In 1879 Professor S. H. Cox‡ discovered in the Manukau district a number of dykes of andesite which near their borders were found to contain small scattered grains of native copper. The dykes are intruded in volcanic breccias of probably younger Miocene age.

Platinum-metals.

Platinum has only been found in a few cases in the matrix *in situ*. In the Ural Mountains it occurs as grains in peridotite, serpentine, and olivine-gabbro. The bed-rock of the

* W. Skey, Trans. N.Z. Inst. vol. xxiii, 1885, p. 401.

† G. H. Ulrich, "On the Discovery, Mode of Occurrence, and Distribution of the Nickel-iron Alloy Awaruite on the West Coast of the South Island of New Zealand," Quart. Jour. Geol. Soc. London, vol. xlvi, p. 619.

‡ S. H. Cox, "Geology of Cape Rodney," N.Z. Geol. Reports and Explorations, 1879–80, p. 27.

Vyzaj and Kaiva Rivers, on the western flanks of the Urals, consists of olivine-gabbro containing disseminated grains of platinum, but not apparently in payable quantities. An olivine rock was discovered in 1893 at Goroblago-datsk, on the western side of the Urals, containing chromite and platinum, the latter at the rate of 14 dwt. 9 gr. to the ton of rock.

Since the discovery of platinum in the nickel-copper sulphide ore at Sudbury, in Canada, careful analysis has disclosed the presence of the metal in minute quantity in many sulphide ores throughout the world. But in this and all cases where platinum occurs in sulphide-beds or in veins, its occurrence is probably not the result of direct magmatic segregation.

ERUPTIVE PROCESSES.

The importance of the *rôle* played by igneous rocks in the formation of ore-deposits has been specially urged in late years by Professor Vogt,* of Christiania; Professor Kemp,† of New York; Professor Suess,‡ of Vienna; and more recently by Waldemar Lindgren§ and W. H. Weed,¶ of the United States Geological Staff.

Vogt directs renewed attention to the close relationship existing between ore-deposits and eruptive processes. Ore-deposits which are generally connected with eruptive magmas are grouped by him into two principal classes, as under:—

(1.) Ore-deposits formed by magmatic segregation.

(2.) Ore-deposits formed by eruptive after-actions.

Ore-deposits belonging to the first group are infrequent, and therefore economically subordinate in importance to those of the second group. They include, according to Vogt,—

(*a*.) The occurrences of titanic-iron ores in basic and semi-basic eruptives;

(*b*.) Chromite in peridotite;

(*c*.) Sulphide deposits, including the nickeliferous pyrrhotite of Sudbury, in Canada;

(*d*.) Platinum metals in highly basic eruptive rocks;

(*e*.) Copper and metallic nickel-iron in serpentinised peridotite.

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* Prof. J. H. L. Vogt, "Problems in the Origin of Ore-deposits," "The Genesis of Ore-deposits," 1901, p. 636.

† J. F. Kemp, "The *Rôle* of the Igneous Rocks in the Formation of Veins," *loc. cit.*, p. 681; also Trans. Amer. Inst. M.E., vol. xxxix, 1902, p. 681.

‡ Prof. Edward Suess, Lecture, "Royal Geographical Journal," vol. xx, 1902, p. 520.

§ Waldemar Lindgren, "Character and Genesis of certain Contact Deposits," "Genesis of Ore-deposits," 1901, p. 716.

¶ W. H. Weed, "Ore-deposits near Igneous Contacts," Trans. Amer. Inst. M.E., vol. xxxiii, 1903.

That sulphides can be segregated from eruptive magmas in the first concentration has yet to be proved; and it is still doubtful how far Vogt's conclusions respecting the occurrence of sulphide ore as products of primary segregation from molten magmas are admissible.

Art. III.—*Contact Metamorphism in its Relation to the Genesis of certain Ore-deposits.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M. (Lond.), F.G.S., Director of the Otago University School of Mines, New Zealand.

[*Read before the Otago Institute, 13th September, 1904.*]

A molten magma tends to effect changes in the rocks with which it comes in contact. In the case of overflow magmas the thermal changes are generally trifling, and in many cases hardly appreciable. Even magmas that have cooled in rents in sedimentaries at shallow depths have not always caused great changes in the enclosing rock.

The greatest alteration will naturally take place in the case of magmas that do not reach the surface, but cool slowly under great pressure. The greater the mass of the intrusive magma, the slower will be the rate of cooling; and the slower the rate of cooling, the longer will the adjacent rocks be heated. The rate of cooling will be mainly dependent upon the mass of the intrusion, the distance from the surface, and the relative thermal conductivity of the adjacent rocks.

The changes effected in the country rock by the intrusion of an igneous magma will be mechanical and hydrothermal. The intruded sedimentaries will be compressed, bent, and more or less shattered and fissured along the line of intrusion. The magma will part with its heat by slow radiation into the adjacent rocks. The magmatic steam and gases, together with the gases generated in the sedimentaries,* will pass into and permeate the latter, and cause a molecular rearrangement of the constituent minerals, resulting in what is termed *contact metamorphism.* As the igneous magma and the heated sedimentaries cool they will contract in area, and when the temperature normal to the depth has been reached

* Professor Joseph Barrell has shown that the heat of an igneous mass acting upon sedimentaries liberates enormous volumes of steam and gases, attended by a shrinkage of volume of the rocks and the formation of vein fissures: "The Physical Effects of Contact Metamorphism," Am. Jour. Sci., vol. xiii, April, 1902, p. 279.

the contraction will tend to cause the two rocks to shrink from each other, resulting in the formation of cavities along the line of contact.

Above a temperature of 365° C. and a pressure of 200 atmospheres, water and all more or less volatile compounds will exist as gas. Aqueous vapours above the critical temperature and under great pressure will act as strongly upon the cooling magma as upon the adjacent rocks. They will possess a solvent power which will be greatest at the depth where the highest temperature and pressure are reached. The pressure will cause the heated steam and gaseous emanations carrying the heavy metals to permeate the bedding-planes of the sedimentaries, and fill all accessible cracks and fissures. In this way bed-impregnation may be effected, and even ore-bodies formed at points some distances from the genetic eruptive magma. A decrease in the temperature and pressure will cause the least soluble substances to be deposited; and as the temperature and pressure continue to diminish, the dissolved substances will be thrown out of solution in the inverse order of their solubility. It is manifest that the later phases of the eruptive after-actions will represent in a modified form the waning effects of solfataric action. The deep-seated conditions will also favour the action of metasomatic processes in the zone of metamorphism, and veins will be formed, some of which may rise to the surface. It is probable that the circulation of the heated mineralised solutions in the later phases will tend to effect a redistribution of the ores and minerals deposited in the earlier stages. In some cases the ascending waters and gases may reach the zone of surface circulation and mix with the meteoric waters, which will then reappear as hot springs, forming ore-bodies and veins not directly in contact with the eruptive magma.

Weed and some other writers have made an attempt to subdivide contact-metamorphic deposits into groups depending mainly upon the mode of occurrence. But the form and mode of distribution may be due to accidents of density or porosity, composition and hydrous condition of the rocks affected, rather than differences in genetic formation. Moreover, the mass of the magma, the weight of superincumbent rocks, the amount of heat and subsequent contraction, and phase of the after-action are all doubtless contributing factors in connection with the form and distribution of the heavy metals. Masses of ore occurring as contact deposits, fissure-veins, and bed-impregnations in the zone of metamorphism may all be traced to the same genetic causes.

Professor L. de Launay, of Paris, supports the views of the school of De Beaumont and Daubrée in respect to the primary influence of volatile mineralisers emanating from eruptive magmas. The emanations, he contends, must have prepared the way by introducing into the enclosing rocks, or simply by depositing in the vein fissures, elements such as sulphides, fluorides, chlorides, &c., which, subsequently dissolved anew by the circulation of superficial waters, have rendered the latter essential aid in the processes of alteration.*

The extent of contact metamorphism effected by the granite intrusions of Albany, in New Hampshire, was fully investigated by Hawes.† His analyses showed a progressive series of changes in the schists as they approached the granite. The rocks are dehydrated, boric and silicic acids have been added to them, and there appears to have been an infusion of alkali on the line of contact. He regarded the schists as having been impregnated by hot vapours and solutions emanating from the granite.

Contact deposits frequently lie at the boundary between the eruptive and the country rock; also at variable distances from the eruptive, but never outside the zone of metamorphism. More particularly, contact ores occur in limestones, marly and clay slates, and are accompanied by the usual contact minerals, garnet, vesuvianite, scapolite, wollastonite, augite, mica, hornblende, &c., and in clay-slate by chiastolite, &c. Contact ores are principally magnetite and specular iron, but sulphides of copper, lead, and zinc often occur. Pyritic contact deposits are typically represented by those of Vegsnas, in Norway; Rio Tinto, Tharsis, and San Domingo, in Spain.

The pyritic ore-mass in Mount Lyell Mine, in Tasmania, is generally described as a contact deposit, although its geologic occurrence does not strictly conform to the common definition of such a body. It is a boat-shaped body lying between talcose schists and conglomerates.‡ The mine-workings have shown that it gradually tapers downwards from the outcrop, being cut off below by a great thrust-plane. There are no eruptives in actual contact with the ore-body, but dykes of diabase and other igneous rocks occur in the district at no great distance. The existence of these dykes and of bands of schist impregnated with sulphides forming *fahlkands* would lead to the belief that there at one time existed channels of communication leading from the eruptive rocks to the vein cavities. It seems probable that the ore-bodies in the Mount Lyell field were formed in the later or solfataric stages of eruptive after-actions.

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* L. de Launay, "The Genesis of Ore-deposits," 1901, Discussion, p. 616.

† G. W. Hawes, Amer. Jour. Sci., vol. xxi, 1881, p. 21.

‡ Prof. J. W. Gregory, "The Mount Lyell Mining Field," Trans. Aust. Inst. Min. Eng., vol. i, part iv, July 1904, p. 281.

Among ore-deposits genetically connected with eruptive after-actions Vogt* includes cassiterite and apatite veins and "ore-deposits of contact-metamorphic zone." Cassiterite deposits are everywhere connected with acid eruptives, principally granite, and occasionally quartz-porphyry and rhyolite. Partly for this reason, and partly because of the characteristic paragenesis of fluoride, borate, and phosphate minerals, he supports the common view that tin-deposits are genetically connected with granitic eruptions, and that various volatile fluorides took part in their formation. Cassiterite veins were formed, he thinks, by pneumatolytic processes†—that is, by the action of gases and water at high temperature and pressure. He further urges that they were formed immediately after the eruption, and before the complete cooling of the granite, one proof of which is the occurrence of tin-vein minerals in veins of pegmatite in the granite.

Cassiterite veins are admittedly independent of the immediately adjacent country rock, and for this reason seem to be more nearly related to deposits of magmatic segregation than to contact-metamorphic deposits.

It is probable that the magmatic segregation of chromite in peridotite was in some cases effected by pneumatolytic agencies before the complete cooling of the magma. It is not uncommon to find chromite in vein-like masses that have the appearance of having been segregated in cavities of contraction in the pasty magma. As the agency of underground water cannot have been active in this class of ore-deposit, the aggregation must have been effected by metal-bearing steam and gases occluded in the igneous magma.

Pegmatite veins, while genetically connected with granitic eruptions, seem to be of later formation than the cassiterite veins. They often pass into quartz, and frequently possess sharp well-defined walls, which suggest their formation in shrinkage-cracks by pneumato-hydatogenetic agencies in the waning phases of the after-actions developed by the progressive cooling of the eruptive magma. The different phases of after-action must necessarily merge into each other, and hence we may expect to find, as we do, tin-vein minerals and even cassiterite in veins of pegmatite.

Among ore-deposits of contact-metamorphic origin Vogt includes the ore-bodies which occur within the metamorphosed contact zone of deep eruptives, especially granite. He distinguishes several types of contact deposit. The Chris-

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* J. H. L. Vogt, "The Genesis of Ore-deposits," New York, 1901, p. 636.

† "Pneumatolysis" is a term first used by Bunsen to describe the combined action of gases and water.

tiania type includes iron-ore deposits that appear to have been formed before the solidification of the granitic magma. These ores are never found in the granite, but always in the adjacent rocks. If they had been introduced after the cooling of the magma they would also have been deposited in the granite. The eruptive magma is believed to be the source of the metal, which is expelled in the heated steam into the surrounding rocks.

The synthetic experiments of Daubrée seem to justify the views of Vogt, Beck, and other observers that cassiterite and pegmatite veins are formed by gaseous and aqueous emanations, and not by direct segregation.

Art. IV.—*Thermal Activity in its Relation to the Genesis of certain Metalliferous Veins.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M. (London), F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

It is manifest that the whole series of eruptive aftẽr-actions will commence at the moment of intrusion of the magma, and continue until the igneous mass has become completely cooled.

Igneous magmas are now admitted by petrologists to contain more or less water together with many constituents of a hydrous or gaseous character. Hence the fusion of magmas is not believed to be pyrogenetic—that is, the result of dry heat alone—but hydato-pyrogenetic—that is, fusion by heat in the presence of water.

According to Arrhenius* water renders the magma more liquid. It has been shown by experiment that magmas which require a temperature of 3,000° Fahr. to produce dry fusion can be fused in the presence of water at 500° Fahr. According to the same distinguished physicist water in a rock magma acts the part of an acid, liberating free silicic acid and free bases.

The activity of water at high temperatures is very great. Barus† has shown that water heated above 185° C. attacks the silicates composing soft glass with remarkable rapidity; and Lemberg has proved experimentally that water at a

* Svante Arrhenius, "Zur Physik des Vulkanismus," Geol. Fören. Forh., Stockholm, 1900.

† C. Barus, "Hot Water and Soft Glass in their Thermodynamic Relations," Am. Jour. Sci. iv, vol. ix, 1900, p. 161.

temperature 210° C. slowly dissolves anhydrous powdered silicates. It is probable that at great depths the pressure will be sufficient to hold the water in the form of a liquid in a superheated condition.* At high temperatures both water and steam possess a great capacity for dissolving mineral substances.

SOLFATARIC—*i.e.*, FORMED BY THERMAL SOLUTIONS AIDED BY STEAM AND GASES.

It is well known that during and after volcanic eruptions there are emitted enormous volumes of steam, also hydrogen-sulphide, sulphur-dioxide, carbon-dioxide, as well as compounds of chlorine, fluorine, and boron. These gaseous and aqueous emanations come from the same source as the igneous magma, accompany the magma in its ascent, and may possibly be one of the contributing causes of the eruption.

Volcanic phenomena can be studied in many parts of the world, but perhaps nowhere with more advantage than in New Zealand. In the volcanic region of the North Island there are thousands of square miles in which volcanic activity can be seen in every stage and phase; there are active, intermittent, and extinct volcanoes, besides innumerable geysers, fumaroles, and hot springs, active, decadent, and dead. The active and intermittent volcanoes discharge their lavas and fragmentary matter from single pipes, or from lateral vents apparently connected with the main pipe, and from fissure rents. The volcanic eruption at Rotomahana in 1886 was from a fissure rent over six miles in length, extending from the summit of Mount Wahanga southward into the basin of Lake Rotomahana, and thence across the rhyolite plateau to Lake Okaro.† The whole length of the rent was the scene of great activity for some weeks after the first great outburst. The geysers, hot springs, and fumaroles occur in isolated groups, or along a line of fissure which often runs along the floor of a valley, or lower flanks of a range of hills. The geysers deposit siliceous and calcareous sinters, mostly the former; and the fumaroles native sulphur. Everywhere the air is pervaded with the smell of sulphur-dioxide. The solfataric action is active, waning, or dead. With the latter the vents are closed up by crustification. Where the

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* C. R. van Hise, "Some Principles controlling the Deposition of Ores," Trans-American Institute of Mining Engineers, vol. xxx, p. 27.

† (1.) Sir James Hector, "On the Recent Volcanic Eruptions at Tarawera," N.Z. Reports of Geol. Explorations, 1886–87, p. 243. (2.) S. Percy Smith, "The Eruption of Tarawera," Wellington, 1886. (3.) Prof. F. W. Hutton, "Report on the Tarawera Volcanic District," Wellington, 1887. (4.) Prof. A. P. Thomas, "Report on the Eruption of Tarawera," Wellington, 1888.

hot springs overflow on the surface they form thick, mushroom-shaped mounds of silica. The silica is sometimes soft and porous, and often dense, hard, and chalcedonic. In all cases the hot springs and geysers are grouped around the volcanic vents, and along fissures in lavas near the point of emission. The waters range from strongly alkaline to acid; and at Rotorua alkaline and acid springs exist side by side. The ascending deep-seated waters are strongly alkaline; while the source of the acid waters is the superficial deposit of pumice which overlies the rhyolite. The pumice in some places contains disseminated marcasite pyrites, and where the alkaline waters come in contact with the pyrites they are oxidized and reach the surface either neutral or acid, according to the degree of oxidation.

In the Hauraki gold-mining area, which adjoins the northern end of this volcanic region, the country rocks consist of a vast pile of andesitic lavas, tuffs, and breccias of younger Tertiary age, resting on slaty shales and greywacke of probably Triassic age. The gold-bearing veins traverse both the andesites and tuffs, but are only productive in the former. They are fissure-veins; but, strictly speaking, they do not conform to the usually accepted definition of a true fissure-vein, since they are generally confined to the igneous-rock formation. Near the borders of the andesites the veins are small and unimportant, and generally die out when they reach the underlying basement rock. On the other hand, the larger and more productive veins are grouped around the old vents, and there seems to be no reason why they should not descend to great depths. In opposition to this view Professor Beck* states that it is inconceivable that mineral deposits could be made from solutions at great depths. The country rock on the walls of the ore-veins is propylitised to a moderately hard grey rock. When two or more veins run parallel with each other, as they do in all the Hauraki mining centres, the country rock between the veins is often entirely altered, or propylitised.

In the Thames district the distance between the numerous parallel veins which traverse the goldfield seldom exceeds 200 yards, and in almost every instance the veins are separated from each other by a narrow belt of hard unaltered andesite. These hard bands, or "bars" as the miners term them, possess the same general strike and dip as the veins, and in cross-section present the appearance of lenticular and hourglass-shaped masses. They vary from a few feet to 30 yards in width. The country rock has been found to be propylitised down to a depth of nearly 1000 ft. below sea-

* Prof. Beck, "Lehre von den Erzlagerstätten," 1901, p. 139.

level, which is the greatest depth reached by mining operations up to the present time. The propylitisation of the andesites is not widespread, but confined to small areas grouped around the old volcanic vents. Away from the eruptive centres the andesites have suffered surface-decomposition, but are not propylitised. The propylitisation was apparently effected by the fissures, which are now veins, having served as channels for the circulation of the hot mineral waters. From these fissures the waters acted on the rock on each wall, and where the fissures were near each other the metasomatic processes operating from one fissure met those coming from the other. Where the processes of alteration did not meet, narrow irregular sheet-like masses of unaltered rock—the "bars" of the miners—were left between the vein fissures.

At Waihi and surrounding districts the veins are chiefly composed of chalcedonic or micro-crystalline quartz, possessing all the characteristics of solfataric origin. Some of the larger lodes can be traced on the surface for a distance of 16,000 ft., but the length of the majority is under 5,000 ft. Besides veins having linear extension, there are many huge mushroom-shaped masses of chalcedonic quartz, closely resembling in form the siliceous deposits now forming in the volcanic regions around Rotorua and Lake Taupo.

At Kuaotunu and Great Barrier Island there are many mushroom-shaped deposits of chalcedonic quartz of great size, in some cases covering hundreds, in others thousands, of acres. At Kuaotunu they are more or less circular in shape, and seldom exceed 20 ft. in thickness.

At Great Barrier Island the largest deposit is of an unusual character.* It is nearly two miles long, half a mile wide, and from 50 ft. to 700 ft. thick. The pipe is completely filled with mineral matter. It has been intersected in four mines in a distance of a mile, and opened up by levels for many hundreds of yards. It varies from 12 ft. to 40 ft. in width, and is filled with very dense banded chalcedonic quartz, in which iron and silver sulphides are sparingly distributed. The evidence furnished by the mine-workings implies that the overlying mushroom or umbrella of quartz was deposited on the surface from thermal water issuing from a long fissure or rent in the andesite.

The molybdenite deposits at Jeff's Camp, in the Hodgkinson Goldfield, in Queensland, are described by W. E. Cameron† as roughly circular or oval-shaped outcrops of

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* J. Park, "The Geology and Veins of Hauraki Goldfields," Trans. N.Z. Inst. Min. Eng., vol. i, 1897, p. 137.

† Walter E. Cameron, "Wolfram and Molybdenite Mining in Queensland," Geol. Survey Report No. 188, Brisbane, 1904, p. 7.

quartz, or "blows," carrying wolfram and native bismuth. The "blows" when followed down develop into irregular pipe-shaped masses surrounded on all sides by granite, which is the country rock. When the quartz is extracted there remain only empty pipes or vents. These pipe-like ore-bodies possess a peculiar genetic interest. They appear to closely resemble the siliceous pipes formed in rhyolite by the hot springs in the Rotorua volcanic region, and the mushroom-shaped quartz blows at Kuaotunu.

There are near Waihi in New Zealand several massive deposits of chalcedonic quartz which are stated by Rutley to be replacements of the andesitic country rock.*

A similar replacement of andesite by silica is described by Spurr as occurring at Monte Cristo district in Washington.† He mentions that the silicification has proceeded until most of the rock is made up of quartz, which, he says, varies from coarsely to very finely crystalline in structure, and contains sulphides, chiefly blende, pyrites, and chalcopyrite. Spurr continues, "Thus we have a complete and gradual transition from andesite to a sulphide ore with quartz gangue, by the progressive replacement of the original materials by silica and metallic sulphides."

In 1894 and 1896 I made an exhaustive examination of the Hauraki andesites for gold and silver. The samples subjected to examination were selected by myself *in situ*. The analyses were conducted by the cyanide test, on samples ranging from 2 lb. to 5 lb. in weight. The pulverised material was leached in glass jars with a 0·3-per-cent. aqueous solution of pure potassium-cyanide for seventy-two hours. The cyanide solutions and washings were evaporated, fluxed with a little pure litharge and borax, and the resulting button of lead cupelled. Simultaneous tests were made so as to check the purity of the litharge and fluxes. All the andesites examined were found to contain gold at the rate of 1 gr. to 1·5 gr. per ton, and silver varying from 3 gr. to 30 gr. per ton of rock. The augite-andesite, at 3,000 ft. from the mouth of the Moanataiari tunnel, contained 1½ gr. of gold and 3 gr. of silver to the ton; and the hypersthene-augite-andesite, from the waterfall in Waiotahi Creek, near the Fame and Fortune Mine, 1½ gr. of gold and 30 gr. of silver.‡

A petrological examination§ of the rocks showed that the

* J. Park and F. Rutley, "Notes on Rhyolites of the Hauraki Goldfields," Quart. Jour. Geol. Soc., London, 55, 1899.

† J. E. Spurr, U.S. Geol. Survey, Twenty-second Annual Report, p. 833.

‡ J. Park, "The Geology and Veins of Hauraki Goldfields," Trans. N.Z. Inst. Min. Eng., 1897, p. 52.

§ J. Park, "Some Andesites from the Thames Goldfields," Trans. N.Z. Inst., vol. xxxiv, p. 435.

feldspars and pyroxenes sometimes showed signs of alteration. The samples were selected from the least-altered rocks obtainable, and in no case did they contain visible pyrites.

The evidence is by no means conclusive that the gold and silver are primary constituents. Whatever the source of the gold may be, I am inclined to agree with Percy Morgan* that the quantity of gold and silver in the veins is too great to be accounted for by the traces existing in the andesite.

Dr. J. R. Don,† in the preparation of his excellent thesis on "The Genesis of certain Auriferous Lodes," made an interesting examination for the presence of gold in the andesites and propylites of the Thames Goldfield. He states that his tests were made upon the concentrates obtained from large samples, by the method of crucible fire assay. His results, in the case of the unaltered andesites, were negative, from which he concluded that these rocks contained no gold. The question that will naturally suggest itself to the mind of the metallurgical chemist, accustomed to the estimation of infinitesimal quantities of gold in cyanide solutions and residues, will be, is the method of crucible or pot assay capable of sufficient refinement to indicate the presence of gold in the proportion of a grain or two to the ton of rock?

My early tests of the Hauraki andesites in 1894 were made by the crucible-assay method. The results, however, were often discordant and unsatisfactory, chiefly on account of the many sources of possible error inherent to the method—errors that it was found impossible to entirely eliminate. Believing that trustworthy results could not be obtained by the pot assay, I adopted a method of leaching the pulverised rock with dilute solutions of potassium-cyanide. By this process larger samples could be tested than by fire assay, and the possible sources of error were reduced to a minimum. The crucible assay is clumsy, laborious, and, in my experience, incapable of the refinement required for the estimation of minute traces of gold even in the hands of the most skilful manipulator.

Luther Wagoner,‡ of San Francisco, who in 1902 made a number of tests for gold and silver in sea-sediments, sandstones, syenite, granite, basalt, diabase, &c., by the cyanide method used by me in 1894 and 1896, arrived independently at the same conclusion. Discussing the assay of rocks, he

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* Percy Morgan, "Notes on the Geology, Quartz Reefs, and Minerals of Waihi Goldfield," Trans. Aust. Inst. Min. Eng., vol. viii, 1902, p. 164.

† J. R. Don, "The Genesis of certain Auriferous Lodes," Trans. Am. Inst. Min. Eng., vol. xxvii, 1898, p. 564.

‡ Luther Wagoner, "The Detection and Estimation of Small Quantities of Gold and Silver," Trans. Am. Inst. Min. Eng., vol. xxxi, 1902, p. 198.

says,* "The statement of Dr. Don that country rocks can be assayed by panning down a quantity and assaying the residue has been tested, as well as the statement that pyrites must be present in order to find gold; and my experiments show that both statements are incorrect—or, at least, not in accord with my experience."

At Te Aroha, near the northern boundary of the central volcanic region, there are in the andesites hot springs; twenty-five miles distant, soda-water springs; and at the Thames, ten miles further north, gas springs which discharge enormous volumes of carbon-dioxide.

In the mines in the north end of the Thames Goldfield the CO_2 issues with great force from cracks and fissures in the rocks. The mine-shafts are situated near the foreshore, and descend to depths varying from 500 ft. to 900 ft. below sea-level. In close muggy weather in summer, with a low barometer, the gas rises in the mines, and, flooding the workings, drives the miners before it. Sometimes the gas rises up to the top of the shafts and overflows at the surface. Notwithstanding the special precautions employed to effect ventilation and to warn the men of danger, several fatal accidents have taken place in the past thirty years.

In the Big Pump shaft the CO_2 escapes with such force as to cause violent boiling all over the surface of the water in the well. The depth of the shaft is 640 ft., but the workings are flooded up to the 500 ft. level, in consequence of which the gas escapes against a head of 150 ft., equal to hydraulic pressure of 65 lb. to the square inch. The commotion at the surface of the water at the 500 ft. level is caused by the escape of the gas which is not dissolved by the water. The pump has been raising water from this shaft for over a quarter of a century at the rate of 750 gallons per minute. The water is so highly charged with gas as to often cause trouble in working the pumps.

At Waihi, Kuaotunu, and Great Barrier Island there are huge veins of quartz, mostly chalcedonic, many of which are still capped with wide mushroom-shaped "quartz blows."

The evidence favours the conclusion that the propylitisation of the andesites and formation of the lodes were the result of hydro-thermal action.

Posepny† mentions the remarkable occurrence of tree-stems changed to galena in the Vesuvian Mine, Freihung, in Bavaria. In these the fibre and annular rings can be easily recognised, being extremely plain on polished surfaces. In the tuff-beds associated with the gold-bearing andesites masses

* *Loc. cit.*, p. 808.

† Prof. Franz Posepny, "The Genesis of Ore-deposits," 1901, p. 129.

of wood partly or wholly silicified and spangled with nests and veins of iron-pyrites are of common occurrence throughout the Hauraki region.

The Martha Lode and its numerous ramifying branches, the Silverton, Union, and Amaranth Lodes, at Waihi, are all contained in an area of about a square mile. The huge lodes, wide zones of silicified andesite, and extensive propylitisation of the andesite, prove that Waihi was an area of intense hydro-thermal activity some time prior to the eruption of the later rhyolite-flows which now form the plains and wrap around the isolated outcrops of andesite containing the Martha and Silverton veins. The propylitisation has already been shown by the Waihi Mine workings to extend to a depth of nearly 800 ft. below present water-level—that is, some 500 ft. below sea-level. Obviously the alteration of the andesite was due to the action of ascending and laterally moving thermal waters.

At Thames and Coromandel some of the most productive veins do not reach the surface of the enclosing rock, and the mine-workings at Waihi have disclosed a similar feature in connection with a few valuable veins in the Waihi Company's property.*

In 1888 Captain F. W. Hutton, as the result of a petrographical examination of the Thames Mining District, concluded that the veins were of hydro-thermal action.†

T. A. Rickard, a well-known American geologist who examined the same goldfield in 1891, when discussing Professor Posepny's paper on "The Genesis of Ore-deposits," describes the characteristic features of the district with the view of adducing additional evidence of the association of thermal springs and later eruptive rocks.‡ He states that his examination of the ore-occurrences and vein-structure, though incomplete, led him to conclude that the deposition of the gold and its associated minerals had followed certain lines of altered country rock which had been exposed to the effects of dying but lingering solfataric agencies.

OHAEAWAI CINNABAR DEPOSITS.

The Ohaeawai Hot Springs quicksilver deposits, on the mainland some distance north of the Hauraki Peninsula, are

* P. C. Morgan, "Notes on the Geology, Quartz Reefs, and Minerals of the Waihi Goldfield," Trans. Aust. Institute of Mining Engineers, vol. viii, 1902, p. 168.

† F. W. Hutton, "On the Rocks of the Hauraki Goldfields," Trans. Aust. Assoc. Adv. Sci., vol. i, 1888, p. 245, and "Source of Gold at the Thames," N.Z. Journal of Science, Vol. i, p. 146.

‡ T. A. Rickard, "The Genesis of Ore-deposits," Discussion, New York, 1901, p. 222.

of great importance on account of the evidence which they furnish in connection with the genesis of solfataric ore-deposits.

The basement rocks consist of marly clays and greensands of Lower Tertiary or Upper Cretaceous age, which are covered with flows of basalt and beds of scoriæ. It is agreed by all geologists that the basalt constitutes the youngest rock-formation in the district. The surrounding country is studded with old craters, and there is everywhere evidence of former intense volcanic activity.

The hot springs around which the quicksilver-deposits are clustered are situated about two miles south-east of Lake Omapere, which itself occupies the site of an old crater. They occur along the edge of a flow of basalt, which is overlain at this point by deposits of calcareous and siliceous sinter and solidified siliceous and carbonaceous muds, through which sulphur and cinnabar are finely disseminated. There are also deposits of pyrites with or without cinnabar, in some cases containing traces of both gold and silver.* The sinters also contain gold and silver.

The ground around the springs is generally very hot, and all attempts to develop the quicksilver-deposits have been frustrated by the large volumes of hot water encountered at shallow depths below the surface.

The district has been examined at different times by Captain Hutton, Sir James Hector, A. McKay, and the author; but the best description is that of André P. Griffiths, who conducted extensive prospecting and mining operations there in 1895 and 1896. The mining operations and borings disclosed many important details which could not be gathered from a surface-examination.

The iron-pyrites occurs in masses near the basalt, and also filling cracks and fissures in that rock. The thickness of the pyritic masses varies from 3 in. to 3 ft., but their other dimensions are extremely irregular. Close to the pyritic masses there is a hard white siliceous sinter from 8 in. to 10 in. thick, which Griffiths found to contain gold and silver in places. One assay of the sinter gave a value of £3 per ton, but unfortunately the proportion of gold and silver is not given.† The cinnabar generally occurs lining small cavities and cracks in the solidified muds and sinters surrounding the original fissures in the basalt. It also occurs impregnating the sinter in an extremely finely divided form. Sulphur occurs throughout the sinter in larger proportion than either the cinnabar or pyrites.

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* André P. Griffiths, "The Ohaeawai Quicksilver-deposits," Trans. N.Z. Inst. Min. Eng., vol. ii, p. 48.

† André P. Griffiths, *loc. cit.*, p. 50.

The hot springs give off large quantities of H_2S, and occasionally a little steam. The gas escaping through the water of the pools and small streams is partially oxidized, liberating sulphur, which imparts a milky-white colour to the pools, locally known as "white lakes." The beaches of the so-called "white lakes" consist of sulphur mixed with magnetic ironsand and a small proportion of alum. Sulphur is also being sublimed at the vents or openings in the rocks from which H_2S and SO_2 gases escape.

The prospecting-work conducted by Griffiths disclosed some interesting features. A deposit of cinnabar and pyrites crops out at the foot of the hills to the south-west of the main deposits. A shaft was sunk near it, and cut the lode at a depth of 35 ft. The ore was 2 ft. thick, and consisted of small crystals of pyrites cemented by cinnabar. At this depth there was a strong evolution of H_2S, and the heat of the rocks increased so rapidly with the depth that mining was extremely difficult.

It is noteworthy that the outcrop of this lode was found close to the charred trunk of a tree partially imbedded in hard siliceous mud. The trunk and roots of the tree were coated with a thin film of cinnabar, as also were some pieces of fossil kauri-gum found near the roots.

A small trench was sunk over a small fumarole; and at a depth of 10 ft. the temperature of the rock was found to be 185° Fahr.

No. 1 borehole, cased with 3 in. piping, was put down to a depth of 104 ft., where it encountered the edge of the basalt. At the same time it struck a fissure from which hot mud was projected a height of 60 ft. for about forty-eight hours. The mud was succeeded by boiling water charged with H_2S gas, which was found to issue at a pressure of 30 lb. per square inch.

Griffiths further mentions that the richest deposits of cinnabar were found in close proximity to the hottest fumaroles, and that at very shallow depths a temperature was soon reached which precluded mining operations being carried on.

The Ohaeawai hot springs cinnabar-deposits, although never likely to be turned to economic account, are of great scientific importance from the light which they throw upon the formation of sulphide ores by solfataric actions. The deposits are still in process of formation, and metallic sulphides have been, and are still being, deposited in underground fissures and at the surface, together with the sinters which form the matrix.

The hot springs and fumaroles owe their existence to the eruption of the basalt, but the basalt is manifestly not the source of the metals. The source may not be deep-seated, but that it exists at some distance below the flow of basalt is almost certain.

The waters of the Ohaeawai springs were found by Captain Hutton in 1870 to contain zinc, manganese, silica, free sulphuric and hydrochloric acids, but not traces of mercury.* A sample of the water analysed by W. Skey in 1896 gave the following results:—

	Grains per Gallon.
Protoxide of iron	2·23
Lime	5·97
Magnesia	1·15
Silica	3·10
Sulphuric acid	13·60
Hydrochloric acid	66·91
Sulphuretted hydrogen	Traces
Alkalies	41·66
Ammonia	Traces
Organic matter	Traces

Comstock Lode.

Abundant evidence of the hydro-thermal origin of veins traversing eruptive rocks is also obtainable in Europe and America.

In several of the mines in the Comstock Lode ascending thermal waters were encountered in the deep workings, and seriously impeded mining operations.† The water which flooded the Gold Hill mines issued from a borehole in the Yellow Jacket Shaft at a depth of 3,080 ft. It had a temperature of 170° Fahr., and was heavily charged with hydrogen-sulphide.‡

Baron von Richthofen,§ who examined the Comstock Lode at a time when no abnormal temperature was noticeable, ascribed the origin of the lode to earlier solfataric action.

Sulphur Bank Cinnabar-deposits.

The quicksilver-mines at Sulphur Bank, in California, furnish important evidence in relation to the genesis of ore-deposits by solfataric action. At this place the basements rocks are slates and sandstones overlain by a fresh-water

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* F. W. Hutton, "On the Occurrence of Native Mercury near Pakaraka, Bay of Islands," Trans. N.Z. Inst., vol. iii, 1871, p. 251.

† Clarence King, U.S. Geological Exploration of Fortieth Parallel, 1870, p. 87.

‡ George F. Becker, "Geology of the Comstock Lode," U.S. Geol. Surv. 1882, p. 230.

§ F. von Richthofen, "The Comstock Lode, its Character and Probable Mode of Continuance in Depth," San Francisco, 1866, p. 54.

formation, which in turn is capped by a flow of basalt. The sandstones and slates are broken and fissured in such a way as to form a breccia. The interspaces are filled partly with a still soft or already indurated siliceous paste, containing finely disseminated metallic sulphides, and partly with cinnabar, for the most part in coherent crusts.* In the same mine the basalt is reduced to a porous mass, and traversed by irregular fissures filled with sulphur and cinnabar.† Hot mineral water and gases carrying H_2S force their way through the interstices of the deposit in the fissured sandstones and slates.

The silica-deposits are found in all stages of consolidation, from a gelatinous mass to chalcedony, and alternate with layers of metallic sulphides, consisting of cinnabar and pyrites.

Unfortunately, no information is obtainable as to the nature of the fresh-water formation lying between the Cretaceous sandstone and basalt.

According to Becker, the hot water is rich in chlorides, borax, and sodium-carbonate. The gases liberated from the water consisted of 893 parts of CO_2, 2 parts of H_2S, 79 parts of marsh-gas (CH_4), and 25 parts of nitrogen, in 1,000 parts.

According to Dr. Melville the marcasite associated with the cinnabar contains traces of gold and copper; and in the efflorescence from the mine-workings Becker detected traces of cobalt and nickel.

In the upper zone only sulphur was found; lower down sulphur and cinnabar, and in depth cinnabar and pyrites occurring upon or within deposits of silica.

STEAMBOAT SPRINGS CINNABAR-DEPOSITS.

The Steamboat Springs in Nevada also furnish important evidence of vein-filling by thermal waters. They have been fully described by Le Conte,‡ Becker,§ and other writers.

In a valley surrounded with eruptive rocks, and underlain by altered sedimentaries believed to be of Archæan age, thermal springs issue from several points from north-and-south fissures. The floor of the valley is covered in places with a sheet of calcareous sinter in which there are many fissures,

* J. Le Conte, "On Mineral Veins now in Progress at Steamboat Springs compared with the same at Sulphur Bank," Am. Jour. of Science, vol. xxv, p. 404.

† Prof. F. Posepny, "The Genesis of Ore-deposits," Trans. Amer. Inst. Min. Eng., vol. xxiii, p. 197.

‡ J. Le Conte, "On Mineral Veins now in Progress at Steamboat Springs compared with the Same at Sulphur Bank," Am. Jour. Sci., vol. xxv, p. 424.

§ G. F. Becker, "Geology of the Quicksilver-deposits of the Pacific Slope," U.S. Geol. Surv., Washington, 1888, p. 331.

here and there still open, but mostly closed by the deposit of silica on their walls. From some of the springs hot vapours and gases, chiefly CO_2 and H_2S, still issue.

Becker found in the mineral water small amounts of mercury-sulphide and sodium-sulphide. About a mile to the west of the main group there are similar fissures yielding steam and CO_2. In the sinters of these occur several metallic sulphides. Becker analysed the filling of several fissures and found, besides hydrated ferric oxide, lead, copper, and mercury sulphide, gold and silver, and traces of zinc, manganese, cobalt, and nickel.

Thermal Action in relation to Vein-formation.

The occurrence of metallic sulphides in the sinters at Sulphur Bank, Steamboat Springs, and Ohaeawai hot springs; the mushroom-capped lodes at Waihi and Great Barrier Island; and the tree-stems replaced by sulphides found in veins at great depths below the present surface, afford conclusive evidence of the filling of veins by hot ascending waters and gases in areas occupied by later eruptive rocks. It is a notorious circumstance that ore-deposits are most numerous in the neighbourhood of extended zones of eruptive rocks, as in Hungary, Transylvania, Nevada, Colorado, and New Zealand, where the vein-bearing rocks are principally andesite, phonolite, and trachyte. In other rocks veins are fewer and more scattered.

For veins in these altered later eruptives Lindgren suggests the name "propylite veins," but it is doubtful whether the genetic difference between propylite veins and true fissure-veins is sufficiently marked to justify the distinction. Moreover, the roots of propylite veins will be difficult to distinguish from fissure-veins connected with a plutonic intrusion.

Professor Suess,* speaking of the importance of the *rôle* played by the waning phases of volcanic phenomena in the formation of mineral veins, says, "Hot springs may be taken as the latest phase of a whole series which led up to the present deposits of ore."

In Nevada the sulphur-bearing rock occurs in beds lying between limestone and magnesian rocks. In Utah the sulphur occurs associated with gypsum near an old crater.

At Tikitere, in New Zealand, there are extensive deposits of sulphur in an old crater. A large proportion of the sulphur is the black amorphous variety. The heat of the fumaroles and hot springs is too great to permit the excavation of the sulphur to a greater depth than 6 ft. or 8 ft.

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* Professor Edward Suess, Lectures, Royal Geographical Journal vol. xx, Nov. 1902, p. 520.

At White Island, in the Bay of Plenty, the deposits of sulphur occur in and around the crater-lake, mixed with gypsum. The crater-water is hot, and highly charged with free hydrochloric and sulphuric acids. The gypsum is deposited in crystalline incrustations on the sides and floor of the crater-lake. The source of the lime has not yet been determined; but the supply must be constant, as gypsum is being deposited continuously. The sulphur is deposited in the water from gas-springs which are seen bubbling everywhere in the floor of the lake; and also from fumaroles around the margin of the crater.

ART. V.—*On the* Rôle *of Metasomatism in the Formation of certain Ore-deposits.*

By Professor JAMES PARK, M.A.Inst.M.E., M.Inst.M. and M. (Lond.), F.G.S., Director of the Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

UNTIL lately it was the common belief that ore-deposits merely filled pre-existing fissures and cavities in the country rock. In recent years, writers on ore-formation have become convinced, as the result of microscopic examination, that many ore-bodies were merely metasomatic replacements of country rock that followed certain well-defined crush-zones or zones of metamorphism. According to this, it is surmised that in many cases no previous cavities existed, but that the waters altered and removed certain tracks or zones of rock which they partially or completely replaced with ore-matter and gangue.

This process of replacement is known to petrologists to have taken place among the constituents of many rock-masses, no matter how dense, including all metamorphic rocks, and all older igneous and eruptive masses. It is known as "metasomatism" (meaning, change of body), and is due to internal chemical reactions which seem to take place as readily in rocks as do the equally obscure metabolic changes in living organisms.

In many cases minerals are replaced molecule by molecule, giving rise to what is termed "mineral pseudomorphism." But in the processes which affect changes in rock-masses, reactions may be set up between the different constituent minerals, thereby forming new minerals capable of segregating themselves into large masses; or the rock may be altered, and some or all of the constituents removed and replaced by new substances. Thus, while pseudomorphism and metasomatism are closely related processes, it is found that they differ widely in the scope of their operation. Gneiss and mica-schist are familiar examples of the work of segregation and molecular rearrangement of the dominant constituents of sedimentary rocks.

The internal changes that affect eruptives are known to every petrologist. Besides these changes, which are chiefly molecular, rock-masses, and especially eruptive rocks, may be so altered by the action of circulating waters as to bear no resemblance to the original rock. Thus, in many cases andesites have been changed to propylite by the removal of certain essential constituents and the substitution of others.

Metasomatic replacement, as defined by Van Hise* and Emmons,† does not necessarily imply a mere substitution of matter, molecule for molecule, as happens in the process of pseudomorphism, which involves the preservation of the original form of the substance replaced, but an interchange of substance, the dissolved rock being replaced by grains or crystalline aggregates of one or more minerals. That substitution did, however, take place in some kinds of deposits is well known. In the tin impregnations found in granite in New South Wales, pseudomorphs of tin in the form of orthoclase are not uncommon; and many other examples could be quoted having reference principally to the replacement of isolated crystals in crystalline and eruptive rocks.

Slow replacement of substance by a progressive movement of the solutions in a definite direction must be assumed to have taken place in the formation of ore-deposits composed of massive aggregates of ore and quartzose matrix. In most cases the direction of movement would be determined by a rock-fracture, fault-line, or crush-zone. In the case of deposits formed by deep-circulating solutions it is manifest that circulation could not be rapid, as the face or breast where metasomatic processes were active would form a blind end or *cul-de-sac*. Whatever circulation existed would be mainly due to convection currents, which in deep-seated cavities would of necessity be feeble.

This raises the question as to the transference and supply of dissolved matter to the continually advancing faces of metasomatic action.

The energy which caused, or, at any rate, accelerated, this transference was probably osmotic pressure, which is a force

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* Van Hise, Sixteenth Annual Report U.S. Geol. Surv., part i, p. 689.

† S. F. Emmons, U.S. Geol. Surv. Monograph xii, p. 565.

of great intensity. It has been proved that when a portion of dissolved substance is deposited from a solution at any point the osmotic balance is disturbed, and immediately more dissolved matter travels to that point, in accordance with the well-established laws of osmotic diffusion, thereby providing new matter to augment the growing mass of ore. Osmotic pressure is the chemical principle which compels solutions to maintain an equal state of concentration throughout their whole mass; and since it is always called into being when precipitation commences, its operation as an agency in vein-filling must not be overlooked.

Metasomatism is a process of lode-formation, and does not concern itself with the source or origin of the dissolved matter contained in the solutions. It is almost certain that metasomatic processes, to a greater or less degree, were active agencies in the formation and filling of the majority of pyritic ore-bodies.

Veins in which the mineral contents are arranged in symmetrical bands or crustifications can only be satisfactorily explained by supposing that the vein-matter was deposited in open channels, beginning with a crust on each wall, followed by subsequent crusts until the channel became closed or the solution exhausted. It is not assumed that the vein fissure remained open its full width during the whole period of deposition of the vein-matter. It is more reasonable to suppose that the fissure gradually opened as the process of deposition proceeded, the newly formed matter affording the necessary support to the walls. The forces which initiated the fracture, if still in existence, would doubtless tend to reopen and widen the fissure from time to time.

Waldemar Lindgren's classic paper on "Metasomatic Processes in Fissure-veins"* represents a great advance in the scientific investigation of vein-formation. The author has followed Stelzner's methods of microscopic chemical research with conspicuous success, in a field hitherto much neglected. His work further shows that a clear understanding of the genesis of a vein can only be obtained by a minute study of the rocks contiguous to the ore-body. The metasomatism he describes is clearly not correlative with the metasomatic replacement defined by Emmons, but merely mineral pseudomorphism on a large scale. He defines his standpoint by repeating and adopting Becker's statement† that "the theory of the substitution of ore for rock is to be accepted only when there is definite evidence of pseudomorphic molecular replacement." He mentions that quartz is found replacing

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* Lindgren, Trans. Amer. Inst. Min. Eng., vol. xxx, 1900, p. 578.
† Becker, Discussion, "Genesis of Ore-deposits," 1901, p. 204.

calcite or even orthoclase, and that rutile and anatase are common as secondary products after ilmenite, titanite, titaniferous magnetite, biotite, &c. Substitution of this kind is pseudomorphic rather than metasomatic. Upon these and other mineralogical replacements which he enumerates he implies that the formation of vein-filling was the result of replacement molecule by molecule.

Lindgren thinks this genetic theory may be fully sufficient for many veins, but admits that for many others, perhaps the majority of fissure-veins, there seems to be something lacking.

Vogt* classifies the metasomatic alterations caused by the circulation of ore-solutions as follows :—

(*a*.) Alterations forming greisen, cassiterite rock, &c.
(*b*.) Scapolitisation.
(*c*.) Propylitisation.
(*d*.) Kaolinisation.
(*e*.) Sericitisation.
(*f*.) Carbonatisation (with dolomitisation).
(*g*.) Silicification.
(*h*.) Zeolitisation.
(*i*.) Intense contact metamorphism.

The tin-bearing rocks at Mount Bischoff, in Tasmania, are eurite and felsite wholly or partly replaced by massive topaz. To the list of metasomatic alteration of rock-masses must therefore be added topazisation.

Vogt agrees with Emmons, Becker, Lindgren, and others that metasomatic replacement plays an important part in the formation of mineral veins and ore-bodies.

Art. VI. — *The Deposition of Mineral Matter from Aqueous Solutions in its Relation to the Filling of Cavities and Vein-fissures.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M. (Lond.), F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

The deposition of metalliferous and mineral matter from underground solutions may be effected by one or more of the following causes :—

(1.) A decrease of temperature.
(2.) A decrease of pressure.

* Prof. Vogt, "Problems in the Geology of Ore-deposits," *loc. cit*, p. 660.

(3.) Electro-chemical action.
(4.) Chemical precipitation—
 (*a*.) By contact with other mineralised solutions.
 (*b*.) By gaseous emanations.
(5.) Absorption of metals from dilute solutions by silica, clays, and porous substances.

The dissolution and deposition of mineral matter from aqueous solutions must necessarily be governed by physico-chemical laws. It is therefore reasonable to assume that the prevailing geological conditions in each case will determine the forces or processes that will be brought into operation.

The dissolving-power of water is enormously increased by heat and pressure, and it has been proved experimentally that water and water-vapour at high temperatures and pressures are capable of dissolving almost all known rocks and metals. Hence water will possess its greatest solvent power at the greatest depth reached by it, whether it is disengaged from a cooling igneous magma, or exists as a deep-seated circulating current. In the first case the water and vapour will gather their mineral contents from the parent magma, either in whole or in part, and in the second case from the rocks through which the channels chance to pass.

The hot mineral-laden solutions will naturally tend to ascend, and in ascending will gradually part with heat and become subject to less pressure. The substances which were dissolved only at the greatest temperature and pressure will be the first to pass out of solution ; and thereafter, as the solutions ascend, with decreasing temperature and pressure, the dissolved substances will be deposited in the inverse order of their solubility. The most difficultly soluble substances will be the first to go out of solution, and the most easily soluble the last. Thus when the ascending waters reach the surface we should only expect to find in solution the easily dissolved alkaline silicates, carbonates, and sulphates.

It is notorious that hot mineral springs do not deposit sulphides at the surface. The cinnabar which has been and is still being deposited in the sinters at Ohaeawai hot springs in New Zealand is being formed from gaseous emanations, and not from the mineral waters. This is also probably true of the cinnabar-deposits at Steamboat Springs and Sulphur Bank in America. At Ohaeawai, Rotorua, and everywhere throughout the volcanic regions of New Zealand solfataric and fumarolic action are intermittent phases of the same pipe or vent. In many cases, however, hot springs and fumaroles exist side by side.

The weathering and oxidation of the outcrops of metalliferous lodes by meteoric waters, followed by the transference and concentration of the valuable contents to a lower depth, forming zones of secondary enrichment, are the work of chemical dissolution and electro-chemical precipitation in which the primary sulphides probably play an important part.

The power possessed by clays, silica, and porous mineral substances to absorb or extract metals from dilute aqueous solutions may play a more important part in the formation of ore-deposits than generally supposed.

W. Skey,* as far back as 1869, proved experimentally that finely pulverised massive quartz, rock-crystal, and silica possess the power of absorbing or extracting the oxide of iron from its acetate solution. He also found that prepared silica especially manifests this property if ignited at a low temperature, and, besides, takes oxides of copper and chromium from their acetate solutions. The more finely divided the silica the more apparent is the absorption.

In 1871 Skey† found that when a weak ammoniacal solution of copper containing a little caustic potash is poured upon a filter of Swedish paper (cellulose), the liquid which passes through the paper is quite or nearly colourless, and the filter is found to have retained all, or nearly all, the copper of such solution.

In 1874 he‡ showed that clay possessed the property of absorbing and fixing natural petroleum in such a way as to form a substance resembling natural oil-shale, the oil being chemically combined with the clay. He does not appear to have tried to ascertain the absorptive power of clay upon solutions of the metals, but his discovery that silica and porous substances such as cellulose possess the property of absorbing metals from their solutions has an important bearing upon the chemistry of ore-formation.

E. Kohler,§ in 1903, experimenting on the line followed by Skey in 1869, showed that clays and porous substances such as gelatinous silica, carbonaceous and colloidal substances, possess the power of extracting metals from their dilute solutions.

In this property of clay, silica, and porous substances we may have found the key to the concentration of gold in the

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* W. Skey, "On the Absorptive Properties of Silica, and its Direct Hydration in Contact with Water," Trans. N.Z. Inst., vol. ii, p. 151, Wellington, N.Z., 1869.

† W. Skey, "Absorption of Copper from its Ammoniacal Solution by Cellulose in Presence of Caustic Potash," Trans. N.Z. Inst., vol. iv, 1871, p. 332.

‡ W. Skey, "Notes on the Formation and Constitution of Torbanite and similar Minerals," Trans. N.Z. Inst, vol. vii, 1874, p. 387.

§ E. Kohler, "Zeitschrift für Praktische Geologie," 1903, p. 49.

clayey and talcose matrix of the remarkable lode-formations of Kalgoorlie; of the rich horn-silver and embolite found in the kaolin clay of Broken Hill Lode; of the silver in the silver-sandstones of Utah; and of the copper in the copper-bearing shales of Mansfield and elsewhere. Rock-impregnation by magmatic water in the zone of metamorphism connected with an igneous intrusion may also be traced to the same cause.

ART. VII.—*The Temperature of Combustion of Methane in the Presence of Palladiumised Asbestos.*

(Abstract.)

By H. G. DENHAM, M.A.

[*Read before the Canterbury Philosophical Society, 7th June, 1905.*]

A CONSIDERABLE doubt appears to envelop the question as to the temperature at which methane combines with oxygen in the presence of palladiumised asbestos. Winkler states that the action scarcely takes place under a red heat. Phillips (Chem. Soc. Jour., 66, 2, 194) gives 404°–414° C.; Hempel, 200°; whilst Richardt has quite recently determined 500° C. as being the temperature at which an appreciable oxidation takes place. It was to throw light on this question that this set of experiments has been carried out.

SCOPE OF WORK.

1. Determination of the temperature of combustion of methane and oxygen when in proper volume for complete combustion.
2. The influence of a change of rate at which the gases were passed over the palladiumised asbestos.
3. The influence of a change in the proportion of the gases.
4. The effect on the temperature of combustion of methane when varying proportions of hydrogen were added.
5. A brief inquiry into the question as to how far the catalytic action of the palladium is due to a superficial oxidation.

APPARATUS AND METHOD.

Pure methane was prepared by the method of Parker and Tribe from zinc-copper couple and methyl iodide; and the oxygen and hydrogen by the electrolysis of pure dilute sulphuric acid.

A heavy iron vessel containing lead, shielded with asbestos walls, was used as a bath, and gave extremely satisfactory results, for rarely did one degree of variation occur in the course of an experiment. All temperatures were measured with a platinum resistance thermometer.

The method adopted was to pass the gas through a capillary containing the asbestos, the tube being kept at the requisite temperature by the lead bath. The gas was then allowed to take up a constant temperature, and carbon-dioxide sought for by absorption in potassium-hydrate.

With regard to testing the oxidation of the metal, the method was altered. Oxygen was slowly passed through the capillary; the apparatus was then swept out with nitrogen, and methane passed through. It was anticipated that, if an oxidation had taken place, traces of carbon-dioxide would be found.

The conclusions arrived at may be summarised as follows:—

1. The temperature of oxidation of pure methane and oxygen is about 520°–546° C., very close to that observed recently by Richardt.

2. An increase in the rate at which the gas is sent over appears to cause a decided increase in the temperature of combustion. Since every particle of gas was in contact with the heated asbestos for over a second, this increase cannot be attributed to insufficient heating. A decrease in the rate caused very little alteration in the temperature of oxidation, showing that increased facilities for combination in no way help to overcome the natural retardation observed by Mallard and Le Chatelier, and by Richardt.

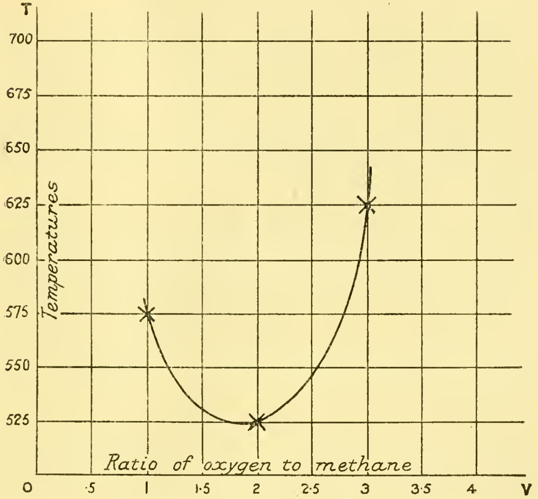
3. A variation in the proportions of the gases causes a decided change in the temperature of oxidation, for a well-defined minimum is obtained when the gases are present in proper volumes for total combustion. 1 vol. CH_4 : 2 of O_2 gave as temperature of combustion 520°–546° C.; 1 vol. CH_4 : 1 of O_2 gave as temperature of combustion 565°–585° C.; 1 vol. CH_4 : 3 of O_2 gave as temperature of combustion 620° C. The curve connecting volumes and temperatures is appended.

4. The addition of hydrogen, even in large quantities, does not cause the methane to burn at a lower temperature. Consequently the usual method of fractional combustion of hydrogen in gas-analyses should give reliable results, provided the temperature does not rise above 500° C. It is interesting to note that the action of the catalyser does not appear to be aided by the intense heat generated by the combustion of the hydrogen. Perhaps the most reasonable explanation of this is that the palladium, which is catalytically active not only towards a methane-and-oxygen mixture but also towards a hydrogen-and-oxygen mixture, acts in the presence of these three gases in such a way as to confine its energy as a catalyser to that direction in which it is the

more active—namely, to aiding the union of hydrogen and oxygen.

5. The catalytic action of the palladium does not appear to be due to a previous oxidation of the metal.

6. In no case has anything approaching complete combustion been observed, although at times the gas was 150° above its temperature of combustion. This is directly contrary to the work of Phillips, but in good accord with the recently published work of Richardt.



In conclusion, I feel that I cannot close this paper without expressing my deep gratitude to Dr. W. P. Evans for his kindly assistance and encouragement, and also to Dr. C. C. Farr for the loan of electrical apparatus.

Art. VIII.—*Technical Analyses of Coal, and Coal-testing.*

By A. M. Wright, M.S.A. (London), Fellow of the German Chemical Society (Berlin).

[*Read before the Canterbury Philosophical Institute, 7th June, 1905.*]

As the results, so far as the estimation of moisture, volatile combustible matter, and fixed carbon are concerned, are only comparative, to be of any value it is necessary that they be obtained under exactly the same conditions.

The methods used for the various determinations in the coals analysed are as follows:—

Moisture.—Weigh 2–5 grams of the pulverised sample into a platinum crucible; place the crucible uncovered in an air bath having a temperature ranging from 105° C. to 110° C., and heat at this temperature for exactly one hour; cool, weigh, and call the loss in weight "moisture." As coal when dried at 100° C. loses in weight for a time, and then grows heavier, the sample cannot be dried in the ordinary way until a constant weight is obtained.

Volatile Combustible Matter.—Weigh 1–2 grams of the sample into a platinum crucible, place the cover on tightly, and heat over a good Bunsen burner for exactly three and a half minutes; then bring a blast lamp under the crucible for exactly three and a half minutes more, taking care not to allow the crucible and contents to cool while changing burners. Cool and weigh, the loss in weight being moisture and volatile combustible matter. This determination should always be made on a fresh sample of coal, and not on the sample used for the moisture-determination.

Fixed Carbon and Ash.—After weighing the crucible for the previous determination, heat over a good Bunsen burner until the carbon is completely burned off and the residue shows no unburned carbon. Cool and weigh; the difference between this weight and the last is the weight of fixed carbon in the coal, and the residue in the crucible is the ash. The sum of percentages of fixed carbon and ash is approximately the percentage of coke that may be obtained from the coal.

Sulphur.—Eschka's method was used, heating with an alcohol-lamp. As this method is well known, no description is needed.

Heating-value.—For the actual calorimetric determinations, Rosenhaim's modification of the Thompson calorimeter was used; for comparison, the calculated heating-values are according to a formula suggested by the American Coal Analyses Committee.*

* Chem. News, 1898, p. 75; Trans. N.Z. Inst., vol. xxxi, p. 564.

TRADE SAMPLES.

—	Moisture.	Ash.	Volatile Combustible Matter.	Fixed Carbon.	Sulphur.	Coal-substance.	Coke.	Heating-value. With Calorimeter (Actual).	Heating-value. Calculated.	Heating-value. Evaporative Power.
								Calories.	Calories.	lb.
Westport (average) ..	3·63	2·75	36·39	57·23	1·58	92·04	59·98	7473·5	7491·3	13·97
Westport (good) ..	2 10	2 27	30·42	65·21	1·24	94·39	67·48	7698·8	7667·3	14·30
Point Elizabeth ..	9·88	0 88	35·95	53·29	1·45	87·79	54·17	7063 3	7142·7	13·32
" ..	10·48	1·63	31·87	56·02	0·97	86·92	57·65	7003·6	7053·2	13·16
Co-operative Coal-mine	5·81	1·12	34·72	58·35	1·35	91·72	59·47	7381·1	7455·9	13·90
Westport Cardiff ..	3 33	1·55	38·28	56·84	1·02	94·10	58·39	7651·8	7635·0	14·24
Puponga	6·78	8 90	33·16	51·16	0·61	83·71	60·06	6895·2	6779·6	12·65
Malvern	25·83	3·96	36·89	33·36	0·68	69·53	37·32	5388·6	5638·5	10·52
Wool-h d Creek ..	26·80	5 45	29·42	3[illegible]·33	1·63	66·12	43·78	5102·4	5401·2	10·07

To determine which coal is the most economical to use, actual boiler tests must be made on each variety as received. Combined with the boiler test should be careful chemical analyses, which will furnish standards of quality for future reference. Alone, chemical analyses are not sufficient, as every boiler requires a particular variety of coal for the production of best results, and then a coal can be selected from which the maximum capacity of heat can be obtained; but, as stated before, this can only be determined accurately by means of actual boiler tests, and subsequently by chemical analyses.

Particularly in rapidly determining the heat-value of successive consignments of the same coal, or of similar coals, the quantity of ash forms the readiest basis of comparison. The ash-determination can be made accurately and rapidly, where it is impracticable to make calorimetric determinations sufficiently often.* Coal high in ash has its fuel-value per ton diminished, and, allowing for the moisture, any variation in the quantity of ash gives a sufficiently good criterion of the variation in calorific value. As the ash accumulates, and is mixed with smaller particles of coal, preventing their complete combustion, the grate is stopped up, thus diminishing the rate of combustion and the steam produced.

From actual calorimetric determinations, compared with the ash-determination of various lots of coal of the same class, the following results show that as the ash increases so the calorific value diminishes, the calculations being made on a 2-per-cent.-moisture basis.

Ash.	Calorific Value.	Ash.	Calorific Value.
2 83	... 7372·2	4·82	... 7150·2
3·01	... 7303·3	4·91	... 7133·8
3·53	... 7279·1	5·45	... 7045·7
3·85	... 7204·6		

Of thirty-two samples of coal examined in this way, twenty-seven, or 84 per cent., varied as above.

As it costs money to handle ash, coals with a high percentage of ash are also more expensive from this standpoint.

Another important factor to be considered is the fusibility of the ash. Coals containing much sulphur produce an ash which is readily fusible, and may thus choke up the grate completely. The completeness of combustion depends greatly upon the absence of fusion in the ash, as, in fusing, the ash

* Jour. Soc. Chem. Ind., 1904, p. 11.

encloses unburned carbon, and thus further combustion is stopped.

An item which does not enter into serious consideration as far as the more commonly used New Zealand coals are concerned is the question of moisture ; this is objectionable, both because of reducing the fuel-value per ton and on account of the heat consumed in evaporating it. A certain amount of the heat produced by fuel is necessary to raise its temperature to that of the grate, as well as for evaporating the moisture contained in it. A fuel very low in heating-value may often use up heat in burning, and thus prove a constant source of loss in heat-energy.

For permission to submit this paper I have to express my thanks to Mr. Gilbert Anderson, managing director of the Christchurch Meat Company, in whose laboratory all the experimental work has been done.

Art. IX.—*Some New Compounds of a Similar Nature to Antifebrine.*

By P. W. Robertson.

[*Read before the Wellington Philosophical Society, 5th July, 1905.*]

Antifebrine, acetanilide, $C_6H_5{\cdot}NH{\cdot}CO{\cdot}CH_3$, is prepared by heating together acetic acid and aniline. The acetic acid may be replaced by any fatty acid, and the resulting compound is known as the anilide of the corresponding acid. Many of these compounds have already been obtained, but the melting-points of the known members of the series show such little regularity that it was determined to prepare the missing members in order to investigate the nature of the irregularities. Again, by treating the derivatives of aniline, such as toluidine, naphthylamine, &c., with the fatty acids, new series of compounds can be obtained, and these have hitherto been investigated only to a slight extent. No less than thirty-five new compounds of this nature have been prepared in a pure condition. Their medicinal properties have not been investigated, but it is quite possible that some of them might prove to be antipyretics as valuable as, if not more valuable than, antifebrine itself.

In Table I are collected the melting-points of the anilides and paratoluidides. It is seen that the numbers do not form a regular series, but vary in a most erratic manner, the irregularities being greatest among the earlier members. In the case of the even members a regular increase in the melting-point is observable after the tenth member, and, further, the differences between the two sets of numbers gradually diminish.

TABLE I.

Number of Carbon-atoms in Corresponding Acid.	Anilides.		Difference.	Paratoluidides.	
	°	°	°	°	°
2	112		...	153	
3		105	...		123
4	90		...	74*	
5		61	...		72*
6	95		...	75*	
7		71	...		80*
8	—		...	59*	
9		57*	...		81*
10	61*		19	80*	
11		64*	...		67*
12	68*		13	81*	
14	84		9	93*	
16	90		6	96*	
18	94		4	98*	

* Determinations by the author.

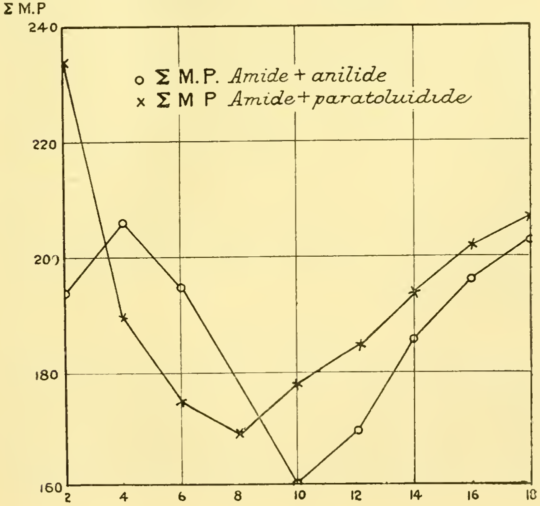
One of the causes of these abnormal results is probably the symmetry of the molecule, which has been shown in many cases to have a great influence on the melting-point. Hence, if in two series of compounds of similar nature symmetry in one case tended to reduce the melting-point, and in the other to cause an elevation, the possibility arises that these two factors might balance each other; consequently, on adding the melting-points together a regular series might result. This method of treatment has proved to be successful, and satisfactory results have been obtained, more especially in the case of the even members, for which the data are more complete.

A series of such a nature is that of the fatty amides, the melting-points of which tend to rise or fall as the corresponding numbers in the case of the anilides or paratoluidides diminish or increase. The values obtained by adding these series together is given in Table II.

TABLE II.—SUM OF MELTING-POINTS.

Number of Carbon-atoms in Corresponding Acid.	Amide and Anilide.		Amide and Paratoluidide.	
	°	°	°	°
2	194		235	
3		184		202
4	205		189	
5		171		187
6	195		175	
7		166		175
8	...		169	
9		149		173
10	159		178	
11		145		148
12	170		183	
14	186		195	
16	196		202	
18	203		207	

In both cases the numbers for the odd members fall continuously. In the even series there is a regular minimum, and in one instance a corresponding maximum at a distance of six carbon-atoms. The resemblance becomes clearer when the results are plotted graphically.



In addition to these compounds the lower members of the naphthylamides have also been prepared. In each case the melting-points form an even less regular series than do the anilides and paratoluidides.

TABLE III.

Number of Carbon-atoms in Corresponding Acid.	α, Naphthyl-amide.	Sum.		β, Naphthyl-amide.
	°			°
2 ...	... 159	291		132
3 ...	... 116*		286	170*
4 ...	... 120*	287		167*
5 ...	... 111*		277	166*
6 ...	... 93*	264		171*
7 ...	... 106*		248	142*
8 ...	... —	—		—
9 ...	... 91*		200	109*
10 ...	... 95*	194		99*
11 ...	... 92*		191	105*
12 ...	... 87*	185		98*

* Determinations by the author.

These series scarcely show any regularity even when the odd and even members are considered separately. But it is noticeable that when the melting-point of the α compound rises, that of the β derivative falls, and *vice versa.* Consequently, on adding the two series together it might be expected that regularities would appear. Such is indeed the case; the sum of the melting-points of the even as well as the odd members forms a gradually diminishing series of numbers.

The naphthylamides, even when recrystallized several times from alcohol, are of a pink or yellowish hue. But the most noticeable feature is that the odd members of the α compounds are much darker in colour than the even members, whilst in the case of the β derivatives exactly the reverse is found to be the case.

EXPERIMENTAL.

The anilides and toluidides described in the present paper were prepared by the following method: A mixture of from 1 to 3 grams of the fatty acid and the equivalent amount of aniline or paratoluidine was sealed in a tube and heated to 150°–180° for eight hours. In no case was any pressure observed in the tube after cooling. The product obtained in this manner was treated several times with dilute hydrochloric acid to separate any uncombined base. After this the impure substance, which if it had first separated as an oil had in most cases now become solid, was washed with water and crystallized from dilute alcohol. Usually three crystallizations were sufficient to obtain a compound of constant melting-point. The yield was in general 50–80 per cent. The purified compound was then analysed by determining the percentage of nitrogen by the ordinary method of Dumas.

The following are the details of the experiments :—

Nonylanilide : $C_{15}H_{23}ON$; white crystals ; M.P., 57°. On analysis, 0·2140 gram gave 11·7 c.c. N at 23°, and 768 mm. N = 6·3 per cent., (calc.) 6 per cent.

Decanilide : $C_{16}H_{25}ON$; white crystals ; M.P., 61°. On analysis, 0·1098 gram gave 5·7 c.c. N at 22°, and 758 mm. N = 5·9 per cent., (calc.) 5·7 per cent.

Undecylanilide : $C_{17}H_{27}ON$; white crystals ; M.P., 64°. On analysis, 0·1968 gram gave 9·6 c.c. N at 23°, and 768 mm. N = 5·6 per cent., (calc.) 5·3 per cent.

Lauranilide : $C_{18}H_{29}ON$; light-yellowish crystals resembling lauric acid ; M.P., 68°. On analysis, 0·3376 gram gave 14·6 c.c. N at 20°, and 770 mm. N = 5·1 per cent., (calc.) 5·0 per cent.

Butyroparatoluidide : $C_{11}H_{15}ON$; white crystals ; M.P., 74°. On analysis, 0·1502 gram gave 10·3 c.c. N at 23°, and 764 mm. N = 8·0 per cent., (calc.) 7·8 per cent.

Valeroparatoluidide : $C_{12}H_{17}ON$; white crystals ; M.P., 72°. On analysis, 0·1474 gram gave 9·6 c.c. N at 19°, and 750 mm. N = 7·5 per cent., (calc.) 7·3 per cent.

Hexoparatoluidide : $C_{13}H_{19}ON$; white crystals ; M.P., 75°. On analysis, 0·2194 gram gave 13·4 c.c. N at 22°, and 754 mm. N = 7·0 per cent., (calc.) 6·8 per cent.

Heptoparatoluidide : $C_{14}H_{21}ON$; white crystals ; M.P., 80 per cent. On analysis, 0·2560 gram gave 14·2 c.c. N at 22°, and 756 mm. N = 6·3 per cent., (calc.) 6·4 per cent.

Octoparatoluidide : $C_{15}H_{23}ON$. Separated as a brown oil, which crystallized only after several weeks. After four recrystallizations a small quantity of the compound, melting constantly at 59°, was obtained. The amount was insufficient for analysis. The small yield in this case is probably due to the fact that it is extremely difficult to prepare octoic acid in a pure state.

Nonylparatoluidide : $C_{16}H_{25}ON$; white waxy crystals ; M.P., 81°. On analysis, 0·1962 gram gave 9·8 c.c. N at 21°, and 754 mm. N = 5·7 per cent., (calc.) 5·7 per cent.

Decoparatoluidide : $C_{17}H_{27}ON$; whitish crystals ; M.P., 80°. On analysis, 0·1646 gram gave 8 Cc.c. N at 23°, and 756 mm. N = 5·5 per cent., (calc.) 5·3 per cent.

Undecylparatoluidide: $C_{18}H_{29}ON$; waxy white crystals; M.P., 67°. On analysis, 0·1924 gram gave 8·5 c.c. N at 23°, and 758 mm. N = 5·0 per cent., (calc.) 5·0 per cent.

Lauroparatoluidide: $C_{19}H_{31}ON$; yellowish crystals; M.P., 81°. On analysis, 0·2780 gram gave 12·1 c.c. N at 22°, and 756 mm. N = 5·0 per cent., (calc.) 4·8 per cent.

Myristoparatoluidide: $C_{21}H_{35}ON$; waxy white crystals; M.P., 93°. On analysis, 0·2042 gram gave 7·6 c.c. N at 21°, and 760 mm. N = 4·35 per cent., (calc.) 4·4 per cent.

Palmitoparatoluidide: $C_{23}H_{39}ON$; yellowish crystals; M.P., 96°. On analysis, 0·2618 gram gave 9·2 c.c. N at 21°, and 764 mm. N = 4·1 per cent., (calc.) 4·05 per cent.

Stearoparatoluidide: $C_{25}H_{43}ON$; after six crystallizations from absolute alcohol the compound melted at 90°. On analysis, 0·2710 gram gave 9·0 c.c. N at 22°, and 764 mm. N = 3·9 per cent., (calc.) 3·75 per cent.

ART. X.—*The Detection and Estimation of the Alkaloids by means of their Double Sulphocyanides.*

By P. W. ROBERTSON, M.A., Rhodes Scholar.

[*Read before the Wellington Philosophical Society, 3rd May, 1905.*]

THE late Mr. Skey, who has enriched the Transactions of the New Zealand Institute by a large number of papers on chemical and physical subjects, has drawn attention to the fact that solutions containing certain alkaloids yield precipitates when treated with ammonium-sulphocyanide and a zinc or mercury salt. Neither the discoverer of the reaction nor any subsequent observer appears to have further investigated these insoluble precipitates. Consequently, at the suggestion of Professor Easterfield, the following investigation was made, with the twofold object of determining the nature of the reaction and of basing upon it a convenient method of volumetric analysis.

The more important alkaloids were examined, and it was found that in the presence of ammonium-sulphocyanide not only zinc and mercury but many other metals gave insoluble precipitates. In particular the cobalt compounds are characterized by the display of colour which occurs during the precipitation. This forms an excellent test for detecting small quantities of antipyrine. If a solution containing cobalt-nitrate and ammonium-sulphocyanide is added to a liquid in which the drug is dissolved, there first appears a dark-blue precipitate, and the colour of the solution gradually changes through various shades of purple till it finally becomes red. Not only is this reaction as sensitive and characteristic as the ordinary tests for antipyrine, but in addition it possesses the advantage that it takes only a short time to perform.

Nickel also gives characteristic green precipitates with quinine and cocaine, but the reaction is not so sensitive as was found to be the case with cobalt. The other metals examined, with the exception of tin, give for the most part only faint precipitates.

The results are collected in Table I, and in the case of the more sensitive reactions the limit of dilution at which the precipitation occurs with excess of the reagents is also given.

TABLE I.—Showing the Reactions of the More Important Alkaloids in the Presence of Ammonium-sulphocyanide and Different Metals.

—	Quinine.	Cinchonine.	Cinchonidine.	Cocaine.	Atropine.	Brucine.	Strychnine.	Morphine.	Codeine.	Nicotine.	Pilocarpin.	Antipyrine.
Zinc ..	White pp. 1 : 50,000	White pp. 1 : 25,000	White pp. 1 : 15,000	White pp. 1 : 10,000	White pp.	White pp. 1 : 4,000	White pp. (faint)	White pp. (faint)	White pp. (faint)	White pp. (faint)	White pp.	White pp. 1 : 1,500
Cadmium	Yellowish pp. 1 : 500	No reaction	White pp. (faint)	Yellowish pp. 1 : 400	No reaction	White pp. (faint)	No reaction	No reaction	No reaction	No reaction	No reaction	Yellow pp.
Cobalt ..	Blue pp. 1 : 1,000	Blue pp.	Blue pp.	Dark-blue pp. 1 : 500	Light-blue pp.	Blue pp.	Ditto	Ditto	Ditto	Ditto	Ditto	Blue pp.
Nickel ..	Dark-green pp. 1 : 500	Faint pp.	No reaction	Green pp. 1 : 300	Faint pp.	Brown pp.	"	"	"	"	"	Green pp.
Manganese	White pp.	No reaction	Ditto	White pp.	No reaction	White pp. (faint)	"	"	"	"	"	Brown pp.
Tin ..	"	Yellow pp.	Yellow pp.	"	Ditto	White pp.	White pp. (faint)	"	White pp.	White pp.	"	White pp.
Magnesium	"	No reaction	No reaction	"	"	No reaction	No reaction	"	No reaction	No reaction	"	No reaction
Thorium ..	No reaction	Ditto	Ditto	No reaction	"	Ditto	Ditto	"	Ditto	Ditto	"	White pp. (faint)

An examination of the above table will show that the cinchona alkaloids, and more especially quinine, give the most sensitive reactions. A solution of ammonium-sulphocyanide and zinc-sulphate compares favourably with the well-known alkaloidal reagents, as is seen from the following data :—

Reagent.	Limit of Proportion of Quinine.
Zinc-ammonium-sulphocyanide ...	1 : 50,000
Phosphotungstic acid	1 : 100,000
Mercury-potassium-iodide ...	1 : 90,000
Potassium-periodide	1 : 80,000
Picric acid	1 : 40,000
Phosophomolybdic acid ...	1 : 30,000
Chlorine and ammonia (thalleioquin)	1 : 20,000

Further, it has the advantages—(1) the reagent is easy to prepare ; (2) it is not extremely sensitive to other alkaloids, as is the case with reagents such as phosphotungstic acid, &c.

Owing to the extreme insolubility of zinc-ammonium-quinine-sulphocyanide, it is evident that the proportion of sulphocyanide in the compound can be found indirectly by determining the excess of sulphocyanide in the filtrate after precipitation. Excess of zinc-sulphate and ammonium-sulphocyanide, however, should be present, as the precipitate is perceptibly soluble in pure water.

As the result of a large number of trials under different experimental conditions, the following method of experiment was finally adopted as being the most convenient for examining the nature of the reaction : Owing to the fact that excess of the reagents are necessary to cause complete precipitation, a strong solution of ammonium-sulphocyanide must be added to the quinine. Then, as the excess of sulphocyanide left in solution after the precipitation is too great to be measured conveniently by the usual method of titration, this strong solution is diluted to a known volume, and then an aliquot portion is taken for analysis.

Ten c.c. of a decinormal solution of quinine dissolved in dilute nitric acid was treated with excess of zinc-sulphate and 10 c.c. of normal ammonium-sulphocyanide. The white flocculent precipitate, which forms immediately, became coherent on agitation, and was separated by filtration through a Gooch crucible. Such a crucible has a perforated bottom, which is covered to a depth of $\frac{1}{8}$ in. with tightly packed threaded asbestos. The crucible is fitted into a thistle funnel with a piece of rubber tubing, and the funnel is fixed in a flask, as shown in Fig. 1. By the aid of a suction pump liquids can be filtered in such an arrangement in a remarkably short space of time.

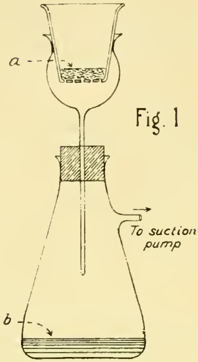


Fig. 1

The precipitate, which remains in *a*, is washed with a small quantity of a solution containing zinc-sulphate and ammonium-nitrate, in which it is practically insoluble.

The liquid which collects in *b* is then transferred to a graduated flask of 100 c.c. capacity. It saves time, however, if the liquid is filtered directly into a measuring-flask to which a side tube is attached (Fig. 2).

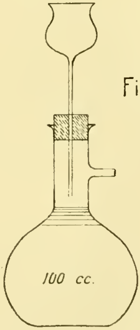


Fig 2

After dilution 10 c.c. of the solution is treated with an equal volume of decinormal silver-nitrate, and $\frac{N}{10}$ sulpho-cyanide added until a red colour is developed with ferric sulphate. Concordant results were obtained at different dilutions, and in the presence of varying amounts of nitric acid, zinc-sulphate, and ammonium-sulphocyanide, provided that excess was present.

The results obtained with a decinormal solution of quinine are given in Table II.

TABLE II.—Showing the Number of Equivalents of Zinc and Sulphocyanide added to One Equivalent of Quinine, the Number of Equivalents of Sulphocyanide removed by the Quinine, and the Total Volume of the Solution.

Quinine.	Zinc.	Sulphocyanide added.	Total Volume.	Sulphocyanide removed.
1	6	10	30	3·5*
1	12	10	30	3·5*
1	6	20	40	3·4
1	12	20	40	3·55
1	6	10	60	3·45
1	12	10	60	3·5

* These results are the mean of a number of closely concordant experiments in solutions with varying amounts of nitric acid.

Similar results were obtained by working with normal potassium-sulphocyanide and washing the precipitate with a solution containing zinc and potassium ions.

From these experiments it appears that one equivalent of quinine combines with three and a half equivalents of sulphocyanide to form the double salt—*i.e.*, 3·5 c.c. N sulphocyanide precipitates 0·324 gram quinine ∴ 1 c.c. N sulphocyanide precipitates 0·093 gram quinine. This method can thus be used for the quantitative estimation of quinine, and it has the great advantage that the whole determination can be performed in a few minutes.

Although cinchonine and cinchonidine do not form such insoluble precipitates as quinine, nevertheless these alkaloids can be satisfactorily determined in a similar manner.

Below is given the sensitiveness of the cinchona alkaloids in the presence of zinc-sulphate and (*a*) ammonium-sulphocyanide, (*b*) potassium-sulphocyanide, at ordinary temperatures.

	Quinine.	Cinchonine.	Cinchonidine.
Ammonium	1 : 50,000	1 : 25,000	1 : 15,000
Potassium	1 : 40,000	1 : 20,000	1 : 12,000

The ammonium-salts are characterized by being slightly less soluble than the corresponding salts of potassium.

It was found in the case of cinchonine and cinchonidine that one equivalent of alkaloid requires three equivalents of sulphocyanide for precipitation—*i.e.*, 3 c.c. N sulphocyanide precipitates 0·294 gram cinchonine or cinchonidine ∴ 1 c.c. N sulphocyanide precipitates 0·098 gram cinchonine or cinchonidine.

This volumetric method of analysis was then compared with the official B.P. methods for estimating quinine in the drug "ferri et quininæ citras," and the total alkaloids in the crude cinchona-bark. Whilst losing nothing in accuracy, the new method effects a considerable reduction in the time and trouble which is expended in the performance of the analysis according to the British Pharmacopœia.

"*Ferri et Quininæ Citras.*"—About 1·5 grams of the substance was dissolved in water, and the quinine was precipitated by ammonia, and extracted with chloroform. The quinine was removed from the chloroform by shaking with 5 per cent. nitric acid, and this solution was titrated as described above. The method of the British Pharmacopœia is to evaporate the chloroform-solution to dryness, and to heat to 100° till the weight is constant. The results obtained by the different methods are as follows :—

B.P. method (time, an hour and a quarter): 1·654 grams gave 0·246 gram quinine = 14·8 per cent.

Titration method (time, half an hour) : (*a*) 1·659 grams required 2·6 c.c. NH_4CNS = 14·6 per cent. ; (*b*) 1·551 grams required 2·4 c.c. NH_4CNS = 14·4 per cent.

The Cinchona Bark (an epitome of the process is given in the adjoining table).—Fifteen grams of the finely powdered material were treated with lime and a small quantity of water. The alkaloids were then extracted with a boiling solution of benzine, containing 20 per cent. of amyl alcohol. This was shaken several times with dilute sulphuric acid, and the solution made up to 100 c.c. So far the method is identical with that of the B.P. Fifty c.c. were diluted to about 200 c.c., heated to boiling and neutralised with ammonia. On cooling the insoluble quinine-sulphate crystallizes out. The usual method of analysis is to collect this on a tared filter, and to heat to 100° till its weight is constant. This operation, however, takes a considerable time, and several weighings are necessary. Further, it often happens that the precipitate of quinine-sulphate separates in such a form that it cannot be conveniently placed on a filter.

In order to estimate the quinine by titration the solution is filtered without troubling to remove the precipitate which adheres to the beaker. After washing with a small quantity of ammonium-sulphate the precipitate on the filter and that left in the beaker is dissolved in a little dilute nitric acid. The amount of quinine in solution is then determined by adding sulphocyanide and titrating as described above.

TABLE III.

Solution containing the acid sulphates of quinine, cinchonine, and cinchonidine from the bark. Dilute to 100 c.c. Take 50 c.c., dilute, heat to boiling, neutralise with ammonia, and cool.

Precipitate. Quinine-sulphate.		Filtrate. Add Rochelle Salt.			
		Precipitate. Cinchonidine-tartrate.		Filtrate, containing Cinchonine.	
Titration Method. Dissolve quinine-sulphate in a little dilute nitric acid and titrate.	*Official Method.* Collect the precipitate on a tared filter and heat to 100° C. till its weight is constant.	*Titration Method.* Dissolve precipitate in a few drops of nitric acid and titrate.	*Official Method.* Collect the precipitate on a tared filter, and heat to 100° C. till its weight is constant.	*Titration Method.* Add nitric acid and titrate.	*Official Method.* Precipitate cinchonine with ammonia, extract with chloroform, heat to dryness, and weigh residue.
Quinine.		Cinchonidine.		Cinchonine.	
Remaining 50 c.c., titrate directly with sulphocyanide.					
Total alkaloid.					

To separate the cinchonidine from the cinchonine the neutral solution from the quinine-sulphate is treated with excess of Rochelle salt and stirred vigorously. After an hour the precipitation is complete. It is usual to weigh the precipitate of cinchonidine-tartrate in the same manner as the quinine-sulphate. It is more rapid and convenient, however, to dissolve the precipitate in a little dilute nitric acid. and to titrate directly with sulphocyanide.

The cinchonine, which is left after the removal of the quinine and cinchonidine, is estimated by acidifying the solution and titrating in the usual manner. Care, however, must be taken to have excess of nitric acid when the silver-nitrate is added.

The remaining 50 c.c. of the original solution is now titrated, and in this manner the amount of total alkaloid can be determined. In the red bark, owing to the small amount of quinine present, 1 c.c. sulphocyanide = 0·097 total alkaloid ; in the yellow bark, 1 c.c. sulphocyanide = 0·095 total alkaloid.

If the method is accurate the total alkaloid (*b*) should be equal to the sum (*a*) of the quinine, cinchonidine, and cinchonine. That this is the case is seen from the following determinations made with a specimen of red bark.

	(1.) Per Cent.	(2.) Per Cent.
Quinine	1·2	1·2
Cinchonidine	2·6	2·8
Cinchonine	1·0	0·9
Total alkaloids ...	(*a*) 4·8	(*a*) 4·9
	(*b*) 5·1	(*b*) 5·0

The same bark was also analysed according to the B.P. method, in which the quinine and cinchonidine are precipitated together as tartrates and the mixture weighed on a tared filter. The cinchonine was estimated by treating the filtrate with ammonia, extracting with chloroform, and heating to dryness.

The results are given below, and compared with those obtained by the titration method.

	P.B. Method.	Titration Method. (1.)	Titration Method. (2.)
Quinine, Cinchonidine ...	4·0	3·8	4·0
Cinchonine ...	1·2	1 0	0·9
Total alkaloids	5·2	4·8	4·9
		5·1	5·0

The Composition of the Double Sulphocyanides.

(*a*.) *Zinc.*

Ten c.c. of the solution of the alkaloid were precipitated in the usual manner with sulphocyanide in the presence of a known excess of zinc-sulphate. The liquid was filtered, and the zinc in the filtrate was estimated by precipitation with sodium-carbonate. From this the amount of zinc which combines with a known amount of alkaloid could be found by difference. The following are the results :—

(1.) Quinine - ammonium - zinc - sulphocyanide : 10 c.c. $\frac{N}{10}$ quinine required 0·0424 gram zinc. Calculated for 3 B, 2 Zn $(CNS)_2$—0·0424 gram zinc.

(2.) Cinchonine-ammonium-zinc-sulphocyanide : 10 c.c. $\frac{N}{10}$ cinchonine required 0·0486 gram zinc. Calculated for 4 B, 3 Zn $(CAS)_2$—0·0487 gram zinc.

(3.) Cinchonine - potassium - zinc - sulphocyanide : 10 c.c. $\frac{N}{10}$ cinchonine required (*a*) 0·0472 gram zinc, (*b*) 0·0494 gram zinc. Calculated for 4 B, 3 Zn $(CNS)_2$—0·0487 gram zinc.

(4.) Cocaine - ammonium - zinc - sulphocyanide : 20 c.c. $\frac{N}{20}$ cocaine required (*a*) 0·0210 gram zinc, (*b*) 0·0232 gram zinc. Calculated for 3 B, Zn $(CNS)_2$—0·0217 gram zinc.

(*b*.) *Ammonia.*

Precipitation was caused by a definite volume of normal ammonium-sulphocyanide in the presence of excess of zinc-sulphate. After washing the precipitate with a small quantity of a dilute solution of zinc-sulphate, the ammonia in the filtrate was estimated by distillation with caustic soda. It was thus possible to determine the amount of ammonia in the double salt.

The method of operation will be illustrated by means of the detailed analytical results obtained in the case of quinine.

Preliminary Test Experiment.—10 c.c. N ammonium-sulphocyanide on distillation with caustic soda gave ammonia = 10·0 c.c. N acid. The filtrate from 10 c.c. $\frac{N}{10}$ quinine and 10 c.c. N ammonium-sulphocyanide gave ammonia = (i) 9·5 c.c. N acid, (ii) 9·5 c.c. N acid. ∴ 1 c.c. N quinine combines with 0·5 c.c. N ammonia.

(*c*.) *Sulphocyanide.*

The method has already been described and explained.

The following is a summary of the results obtained in the determination of ammonia and sulphocyanide :—

(1.) Quinine - ammonium - zinc - sulphocyanide : 10 c.c. $\frac{N}{10}$ quinine required (*a*) 0·5 c.c. N ammonia and 3·5 c.c.* sulpho-

* The mean of a large number of closely concordant determinations.

cyanide, (*b*) 0·5 c.c. N ammonia. Calculated for 6 B, 4 Zn $(CNS)_2$, 3 NH_4CNS, 10 HCNS, 0·5—3·5 c.c. sulphocyanide.

(2.) Cinchonine - ammonium - zinc - sulphocyanide : 10 c.c. $\frac{N}{10}$ cinchonine required (*a*) 0·5 c.c. N ammonia and 3·0 c.c.* sulphocyanide, (*b*) 0·55 c.c. N ammonia. Calculated for 4 B, 3 Zn $(CNS)_2$, 2 NH_4CNS, 4 HCNS, 0·5 — 3·0 c.c. N sulphocyanide.

(3.) Cocaine - ammonium - zinc - sulphocyanide : 20 c.c. $\frac{N}{20}$ cocaine required (*a*) 0·5 c.c. N ammonia and 2·5 c.c.* N sulphocyanide, (*b*) 0·55 c.c. N ammonia. Calculated for 6 B, 2 Zn $(CNS)_2$. 3 NH_4CNS, 8 HCNS, 0·5 — 2·5 c.c. N sulphocyanide.

(*d.*) *Alkaloid.*

The precipitate from a known amount of alkaloid was collected on a Gooch crucible, and dried in a vacuum over sulphuric acid. Under these conditions the double salts still persistently retain a trace of water, which was removed by heating to 100°. The weights thus obtained should confirm those calculated from the formulæ, which were derived from the analytical results already given above.

(1.) Quinine - ammonium - zinc - sulphocyanide : Quinine = (*a*) 54·6 per cent., (*b*) 55·0 per cent. Calculated for 6 B, 4 Zn $(CNS)_2$, 3 NH_4CNS, 10 HCNS—55·6 per cent.

(2.) Cinchonine - ammonium - zinc - sulphocyanide : Cinchonine = 54·9 per cent. Calculated for 4 B, 3 Zn $(CNS)_2$, 2 NH_4CNS, 4 HCNS—55·7 per cent.

(3.) Cinchonine-potassium-zinc-sulphocyanide : Cinchonine = 55·4 per cent. Calculated for 4 B, 3 Zn (CNS_2), 2 KCNS, 4 HCNS—55·6 per cent.

(4.) Cocaine - ammonium - zinc - sulphocyanide : This compound could not be dried without decomposition.

Summary and Conclusion.

1. Whereas many alkaloids give insoluble with ammonium- or potassium - sulphocyanide and zinc - sulphate, the double salts of quinine, cinchonine, cinchonidine, and cocaine are the most insoluble in the presence of excess of the reagents.

2. These double salts are exceedingly complex in their composition, a characteristic of many alkaloidal compounds. Thus, cinchonine - ammonium - zinc - sulphocyanide has the formula, 4 $(C_{19}H_{22}N_2O)$, 3 Zn $(CNS)_2$, 2 NH_4CNS, 4 HCNS. This corresponds closely with the formula of herepathite or sulphate of iodo-quinine, which may be written, 4 $(C_{20}H_{24}N_2O_2)$, 3 H_2SO_4, 2 HI, 4 I_2, + 3 aq.

* The mean of a large number of closely concordant determinations.

3. Notwithstanding the complexity of these insoluble compounds, the determination of the amount of sulphocyanide required by the alkaloids for their formation serves as the basis of an accurate and speedy method of estimating quinine in the commercial drugs, and of assaying the crude cinchona-bark.

Experiments are now in progress to ascertain if this method may prove of value in estimating cocaine in the commercial preparations and in the assay of coca-leaves. With suitable modifications it may also serve as a means of separating different alkaloids, such as strychnine and brucine, or quinine and strychnine.

The above work was carried out in the Victoria College Laboratory, Wellington, under the conditions of the Jacob Joseph Scholarship.

ART. XI.—*Notes on the Hemiptera of the "Index Faunæ Novæ-Zealandiæ."*

By G. W. KIRKALDY.

[*Read before the Philosophical Institute of Canterbury, 7th June, 1905.*]

ZOOLOGISTS will be indebted to Captain Hutton for his reduction of the "Index," certainly no light task; but it is a pity that the nomenclature of the *Hemiptera* was not brought up to date, as many of the species are now placed in genera other than those in which they were originally described. It would require a new list to present this corrected nomenclature, but the following notes may be useful :—

P. 221. (*a.*) For *Nezara amoyti* read *N. amyoti.*

(*b.*) *Oncacontias vittatus* (Fabr.) = *Cimex vittatus*, Fabr. = *Anubis vittatus*, Index = *Acanthosoma vittata*, Distant, 1900, Ann. Mag. N.H. (7), vi, 227 = *Oncacontias brunneipennis*, Breddin, 1903, S.B. Ges. Nat. Fr. Berlin, 219. Breddin's genus may be held, though the distinction from *Acanthosoma* is very slight. I can add Palmerston North (Quail) as a locality.

ADDITIONAL SPECIES AND VARIETIES.

Fam. CERCOPIDÆ.

Ptyelus (*Phlænus ! sic*, Index) *trimaculatus*, Walker, vars. *tristis* and *lætus*, Alfken, 1904, Zool. Jahrb. Sys., xix, 598.

Fam. CHERMIDÆ (*Psyllidæ*, Index).

Psyllia acaciæ, Maskell, 1894, Ent. Mo. Mag. xxx, 171; also found in Australia and Tasmania, probably introduced.

Powellia vitreoradiata, Maskell, 1879, T.N.Z.I., xi, 223, pl. viii, f. 22.

Powellia doryphora, Maskell, 1880, *l.c.*, xii, 291.

Trioza alexina, Marriner, 1903, T.N.Z.I., xxxv, 305, pls. 33, 34.

Probable Incorrect Inclusions.

The following species should be expunged from New Zealand lists till further confirmations. It is well known that many of the localities given in the voyages of the "Novara," "Eugenie," &c., are incorrect.

Fam. Cimicidæ (*Pentatomidæ*, Index).

Calliphara imperialis (included in T.N.Z.I., xxx, p. 169, but omitted in Index).

Scutiphora pedicellata (included in T.N.Z.I., xxx, p. 169, but omitted in Index).

Sciocoris helferi.

Platycoris immarginatus.

Fam. Macrocephalidæ (*Phymatidæ*, Index).

Phymata feredayi and *conspicua* : These are both the same (American) species, and were either accidentally introduced into New Zealand or were incorrectly labelled.

Fam. Reduviidæ.

Nabis lineatus : Probably included in error.

New Name.

The genus *Morna*, White, is preoccupied in the same order. In his Nomenclator Zool., p. 217, Scudder records, "*Morna*, White, Ent. Month. Mag., xv., p. 130 (= *Romna*, White); 1878, *Hem.*, White." I do not think this can be taken as a proposal of *Romna* as a new name by Scudder, especially as it is not included in its place in the list on page 281; and it seems best to establish *Romna* definitely now as a new name, and entomologists can quote either *Romna*, Scudder (or White?), 1882, or *Romna*, Kirkaldy, 1905, as they think fit.

I may add that I am working out the life-history of several Hawaiian *Hemiptera*, especially at present *Œchalia griseus* and *Hyalopeplus pellucidus*.

I should be much obliged for specimens (in all stages, preferably preserved in alcohol) of any Novo-Zealandian *Hemiptera*, especially *Œchalia consocialis* (*Schellembergii*), and any of the *Capsidæ*.

Art. XII.—*Note on a Water-beetle found in Sea-water.*

By Charles Chilton, M.A., D.Sc., F.L.S., Professor of Biology at Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 7th June, 1905.*]

In January, 1905, while searching in the rock-pools at Island Bay, Wellington, for marine animals, I found a water-beetle swimming freely among the seaweed in one of the pools. Only the one specimen was seen, but it seemed quite at home, and was behaving just as it might have done in fresh water. As its occurrence in salt water appeared rather unusual, the specimen was forwarded to Dr. David Sharp, of Cambridge, England.

He informs me that it is *Rhantus pulverosus*, Stephens, a species already known from New Zealand and elsewhere, and that, as it is sometimes found in brackish ditches and streams near the sea, there is a probability that it had been passively carried out to sea by a flood; at the same time he points out that the distribution of this and of some other species can only be explained by supposing that they are capable of living in the ocean for a time, and, if a suitable object presents itself to give them a starting-point, of taking fresh flights from time to time.

There is a small stream at Island Bay which opens into the sea not very far from the place where the beetle was captured, and it is quite likely that it may have been carried into the sea from the stream during a flood; but even if it is so the beetle must be capable of living for some time in actual sea-water, for the pool in which it was taken was freely exposed to the inflow of the waves at all times except at dead low tide, and the stream was at such a distance and the volume of water in it so very inconsiderable that it could make no appreciable effect on the salinity of the water in the rock-pools.

Darwin in his "Voyage of the 'Beagle'" records the finding of several live water-beetles swimming in the ocean seventeen miles from land, off Cape Corrientes, and considers that they had been floated into the sea from a small stream which drains a lake near the cape. He also records the finding of a species of *Hydrophilus* in a lagoon near Rio Janeiro in which the water was only a little less salt than in the sea.

I have thought it worth while to record the above facts, for exceptional occurrences of this kind are often of special value in the explanation of difficult questions that may arise in connection with geographical distribution.

Art. XIII.—*Note on the Occurrence of* Metoponorthus pruinosus, *Brandt, in New Zealand.*

By Charles Chilton, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 7th June, 1905.*]

In the list of *Crustacea* in the British Museum published in 1847, a species, *Porcellio zealandicus*, is named but not described (p. 99). It remained undescribed till 1876, when Miers, in preparing a catalogue of the New Zealand *Crustacea*, examined all the New Zealand *Crustacea* in the collections of the British Museum and described those he considered new. His description of *Porcellio zealandicus* appeared first in the "Annals and Magazine of Natural History" (ser. 4), xvii, p. 225, and was also given in the "Catalogue of New Zealand *Crustacea*," and was there illustrated by two figures.

In the "Crustacea Isopoda Terrestria," published in 1885, Budde-Lund put down the species as a doubtful synonym of *Metoponorthus pruinosus*, Brandt. Up to that time, and for long afterwards, no local collector had recognised the species; and in my "Terrestrial Isopoda of New Zealand"* I could only add to the account given above that I had examined the type specimen in the British Museum, and that it was undoubtedly a *Metoponorthus*, and apparently closely resembled *M. pruinosus*, though the condition of the specimen was not sufficiently good to allow one to be quite sure on this point. I also pointed out that, while it would not be extraordinary if this cosmopolitan species were found in New Zealand, still it was not known to local collectors up to that time; though, as the British Museum specimen must have been obtained before 1847,† we might have imagined that the species, if really existing in New Zealand at that time, would have since become abundant.

In 1901 I recognised numerous specimens of *Metoponorthus pruinosus* among *Isopoda* sent from Norfolk Island, but none from New Zealand till March, 1905, when among some *Crustacea* sent me by Mr. Hutchinson from the shores of a tidal lagoon in Hawke's Bay I found numerous specimens of this species. I have compared them with the Norfolk Island specimens, and also with specimens gathered in England, and find that they are all specifically identical.

* Trans. Linn. Soc., 2nd ser., Zool., viii, p. 141.

† Since this was written Dr. T. W. Calman, of the British Museum, informs me that it is not quite correct. The specimens recorded by White in 1847 were from "Van Diemen's Land"; that from New Zealand, described by Miers, was received by the Museum in 1854.

There is therefore no longer any reason for doubting that this widespread species had established itself in New Zealand even before 1854. It is interesting to note, however, that it does not appear to have spread widely in New Zealand. I have certainly never seen it in the South Island, where I have collected pretty widely for many years past; and, though I have not personally collected it in the North Island except near Wellington, I have had many terrestrial isopods sent me from different places in that Island, but no *Metoponorthus pruinosus* till I got those sent by Mr. Hutchinson.

The same thing is true of another introduced species, *Armadillidium vulgare*, Latr., which is common in the City of Nelson, but has so far not been recorded from any other part of New Zealand except Mount Egmont, whence a single specimen was sent me years ago by the late Mr. Drew. On the other hand, *Porcellio scaber*, Latr., another introduced species, is extremely common all over New Zealand, and, in addition to being found near inhabitated places, has penetrated to some extent into the bush far from houses.

ART. XIV.—*On* Crassatellites trailli.

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 7th June, 1905.*]

A SPECIMEN of this species collected by Professor James Park, F.G.S., and presented by him to the Canterbury Museum, shows a well-marked pallial sinus. It therefore cannot be kept in the genus in which I originally placed it, but appears to belong to *Mactropsis* of Conrad. It resembles the *Mactridæ* in having a prosogyrous beak, but otherwise it is more like the *Mesodesmidæ*, in which it is usually placed. The following is a description of the species.

MACTROPSIS TRAILLI.

Crassatella trailli, Hutton, Cat. Tertiary Mollusca of New Zealand, 1873, p. 24.

Shell solid, heavy, closed at both ends, elongato-triangular, very inequilateral, produced, flattened and roundly angulate posteriorly. Anterior end rounded; posterior end obliquely truncated. Both anterior and posterior dorsal margins nearly straight; ventral margin slightly curved. Umbones slightly prosogyrous. Exterior finely and regularly concentrically ribbed; the ribs rounded, rather narrower than the grooves, becoming obsolete on the posterior flattened slope of the shell, as well as near the ventral margin. Lunule well marked, lanceolate, smooth. Margins smooth. Adductor scars deep, about equal in size. Pallial sinus well marked, rounded. Resillifer flat and triangular, similar in both valves. Right valve with two cardinal teeth, the central one very strong and much higher than the anterior. Anterior lateral tooth obsolete; posterior lateral strong. Left valve with two cardinal teeth; the posterior lateral obsolete, the anterior well developed.

Length, 55 mm.; height, 35 mm.; thickness, 21 mm.; depth of pallial sinus, 7 mm.

Localities.—Wharekuri, Waitaki Valley; Mount Harris; Mount Horrible; Pareora; Awamoa.

Art. XV.—*On a Skeleton of* Emeus crassus *from the North Island.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 7th June, 1905.*]

On the 31st January last the Museum received from Mr. C. K. Meredith-Kaye an imperfect skeleton of a moa, which turned out to be *Emeus crassus*. It was found in sand by Mr. Meredith-Kaye's son, on his run, about eighteen miles south of Castle Point, on the east coast of Wellington Province.

With the exception of the legs and feet, the bones were brittle and much broken; nevertheless it is quite possible to make out the characteristics of the bird. The remains are—skull and premaxilla, with the right maxillo-palatine and both quadrates; the entoglossal bones; nineteen vertebræ, from 10 to 28; a very imperfect pelvis, with nine caudal vertebræ; a fragmentary sternum, and the remains of fourteen thoracic ribs, with five uncinates; two cervical and seven sternal ribs; a set of leg and toe bones complete, except one hallux missing. There were also about thirty-five slender oval and fifty thick round tracheal rings. Many others were destroyed, as they hardly bore handling. It was a full-grown bird, but the twenty-eighth vertebra was not anchylosed to the pelvis.

With the skeleton were found a few rounded pebbles of sandstone, and three fragments of egg-shell; the latter showing that the bird was a female, for the place in which the skeleton was found precludes us from supposing that it might have been a male sitting on an egg.

Of the skull: The calvarium is well preserved, the premaxilla is damaged but resembles that of *Emeus*, but the mandible is altogether absent. The right maxillo-palatine is like that of *Emeus*, there being no atrium to the palatine. The skull resembles that of *Emeus crassus*, but the temporal ridges advance more over the cranial roof, the occipital condyle does not project so much, and its neck is thicker. The paroccipital processes descend as low as the basitemporal platform. The zygomatic process is long and simple. The anterior lambdoidal ridge makes an angle in the centre of the skull, as in *Anomalopteryx*. The mammillar tuberosities are small. The dimensions are: Length of the basis-cranii 35 mm., of roof of cranium 76 mm.; width of cranium at paroccipital processes 64 mm., width at squamosal processes 72 mm., at temporal fossæ 40 mm., at postorbital processes 81 mm.; distance between temporal ridges, 36 mm.; height of cranium, 46 mm.; width of tympanic cavity, 18 mm.; width of temporal fossa, 20 mm.; width of orbit, 31 mm.; distance between optic foramina, 10 mm.; length of quadrate, 34 mm.; greatest length of premaxilla, 78 mm.; width of the body, 36 mm.(?)

The vertebral column commences with No. 10. All the seven thoracic vertebræ are present. They resemble those of *Emeus* in every particular.

The sternum is much broken, but sufficiently well preserved to show that it belongs to *Emeus*. The width across the costal processes is about 173 mm.; the width of the body is 110 mm.; and the length of the body 112 mm.(?)

The pelvis is very incomplete. The ventral surfaces of the sacral vertebræ are broad and flattened, but without any longitudinal ridge. The width at the antitrochanters is 305 mm.

The leg-bones include both the tarsals: they resemble those of *E. crassus*. The following are the dimensions: *Metatarsus:* Length, 203 mm.; prox. width, 88 mm.; mid. width, 48 mm.; dist. width, 106 mm. *Tibia:* Length, 482 mm.; prox. width, 148 mm.; mid. width, 46 mm.; dist. width, 76 mm. *Femur:* Length, 268 mm.; prox. width, 99 mm.; mid. width, 46 mm.; dist. width, 117 mm. It will thus be seen that the femur is shorter than in *E. crassus* from the South Island. The right metatarsus has the anterior openings of the interosseal canals about ½ in. apart, but in the left the anterior opening of the entinterosseal canal is absent, while that of the ectinterosseal is enlarged and divided by a bony ridge. Both posterior openings are present. This is a common variation in the *Dinornithidæ*.

The feet have only four phalanges in the outer toe, as is usual in *Emeus*. The third and ungual phalanges of the right outer toe are diseased, and there is an osseous growth at the distal end of the right femur.

I conclude, therefore, that the bird belongs to *E. crassus*, although it is remarkable that no bones of this species have hitherto been found in the North Island. The knowledge of the sex of the bird also adds to the importance of this skeleton, which has been mounted and is preserved in the Canterbury Museum.

Art. XVI. — *Results of Dredging on the Continental Shelf of New Zealand.*

By Charles Hedley, F.L.S.

[*Read before the Wellington Philosophical Society, 7th June, 1905.*]

Plates I and II.

Introduction.

During the meeting in January, 1904, of the Australasian Association for the Advancement of Science, at Dunedin, a party of the assembled zoologists proposed to attempt some deep-sea dredging. The project received the cordial sympathy of the President, Professor T. W. E. David, F.R.S., who referred to it in his presidential address.

To Professor Benham, Messrs. A. Hamilton, G. M. Thomson, and the writer, the use of a steamer was generously granted by the Dunedin Harbour Board. We gratefully acknowledge also the assistance of the Union Steamship Company of New Zealand, who provided us with deep-sea sounding apparatus, and the services of two of their officers to operate it.

I had brought with me from Sydney several hundred fathoms of wire rope and a dredging-bucket of my own design which had done good service on similar occasions. The latter may be briefly described as a conical bucket, the aperture of which was choked by a movable inverted truncated metal cone, like that fitted to the mouth of a rain-gauge.

The day appointed for the excursion was unfortunately spoilt by rough weather. We spent twelve hours of the 14th January in great discomfort, sounding and dredging about twelve to twenty miles outside Port Chalmers, in from 100 to 300 fathoms. As a result we lost considerable gear, and obtained only a cupful of bottom from 100 fathoms. The bucket dredge appeared to fill properly, and was raised to within a few fathoms of the surface when the line parted. It seemed to be twisted off. This accident I attribute to the want of a swivel link.

A second expedition was later organized in Auckland, where Professor Park, Rev. W. H. Webster, Messrs. H. Suter, R. Murdoch, and C. Cooper joined the writer. The bucket lost off Port Chalmers was replaced by one built by a local tradesman. A serviceable vessel, the "Awarua," fitted with steam winding-gear, was engaged for the trip.

On passing out to the open sea from the Hauraki Gulf we encountered a heavy swell, and found that the gale which had proved so disastrous to the Dunedin excursion had followed us up the coast. The success ultimately achieved was largely due to a happy suggestion of Mr. Cooper. By his advice we packed a sack with cotton-waste and poured therein a couple of bottles of machine-oil. Trailing this over the ship's side as we drifted, a zone of calm water afforded us protection while we dredged.

The spot selected for operations was in the vicinity of Cuvier Island, east of Great Barrier Island, in S. lat. 36° 8′, E. long. 175° 55′; depth, 110 fathoms. The time, sunrise on the 22nd January, 1904.

At or about the 100-fathom zone the submarine slope here, as elsewhere in New Zealand or East Australia, suddenly changes to a steeper descent. I have met with no explanation of this phenomenon, and now venture to suggest that this alteration marks the lowest point at which currents have transported material.*

After twenty minutes' winding, the bucket came up full to overflowing with soft, sticky, green mud. A second haul produced similar results. A few echini were entangled in frayed rope-yarn attached to the small end of the bucket.

We returned to Auckland with about a third of a ton of sea-bottom. Mr. Cooper hospitably gave the party the use of his premises. After reserving samples for geological examination, the mud was placed in fine sieves, on which was played the garden-hose. On preliminary examination the mud, which was perhaps coloured by glauconite, showed but few shells; washing yielded about a spoonful of shells to a gallon of mud. An interesting feature is the occurrence of several species, such as *Poroleda lanceolata* and *Loripes concinna*, previously only known as Tertiary fossils.

It was resolved by the company that Mr. Suter take charge of the collections and distribute different groups to specialists who might undertake their study, and that types of new species should be ultimately placed in the Colonial Museum.

Under this arrangement the examination of the following *Mollusca* has been assigned to me. My labours have been much lightened by the kindness of Messrs. Suter and Murdoch, who sorted out the species and assisted me with preliminary determinations.

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* Since writing the above I find that Admiral Wharton has already advanced this explanation—"Nature," 25th February, 1897, p. 392.

Pelecypoda.

Nucula lacunosa, Hutton.

Nucula sulcata, A. Adams, P.Z.S., 1856, p. 53. *Id.*, Thes. Conch., iii, 1860, p. 153, pl. 229, f. 127 (not of Brown). *N. lacunosa*, Hutton, P.L.S.N.S.W., ix, 1884, p. 528.

Several specimens in which the radii are more prominent than in shallow-water specimens.

Nucula nitidula, A. Adams.

Nucula nitidula, A. Adams, P.Z.S., 1856, p. 51. *Id.*, Thes. Conch., iii, 1860, p. 150, pl. 229, f. 142.

A few specimens were procured.

Leda bellula, A. Adams.

Leda bellula, A. Adams, P.Z.S., 1856, p. 49. *Id.*, Hanley, Thes. Conch., iii, 1860, p. 122, pl. 228, f. 74.

A species which occurred abundantly answers fairly to the above quotations. But the lithograph, fig. 25 of pl. v, "*Leda*," in Conch. Icon., vol. xviii, is so bad a copy of the figure in the Thesaurus that it looks like a different species.

A. Adams, whose name is the danger-signal for untrustworthy work, reports the species as taken by F. Strange in Australia. But, on the one hand, no Australian shell like this is known to me, and, on the other, Strange collected extensively in New Zealand. Indeed, he was the first, and for half a century the last, to dredge off the New Zealand coast, and discovered many of the species enumerated in this report. I am therefore disposed to think that "Australia" has been substituted here for "New Zealand." The species before me is that known to all conchologists in New Zealand as *Leda concinna*. The figures of *Leda concinna* more nearly express the proportions of *Poroleda lanceolata* than any other member of the New Zealand fauna, and are incompatible with the traditional determination.

Leda fastidiosa, A. Adams. Plate I, figs. 1, 2.

Leda fastidiosa, A. Adams, P.Z.S., 1856, p. 49. *Id.*, Hanley, Thes. Conch., iii, 1860, p. 125, pl. 228, f. 82, 83.

A considerable number were dredged. The concentric sulci vary from the least trace to considerable development, but are never so coarse and regular as in the last species. Besides being smoother than *L. bellula* it is more inflated, and is further distinguished by a microscopic punctate pattern. The length of the figured specimen is 7 mm. and the height 4 mm.

This species was first described from New Zealand, probably from Strange's collection, but has never been recognised again, either there or elsewhere, and was eliminated from the New Zealand list by Hutton (P.L.S.N.S.W., ix, 1884, p. 527).

Poroleda lanceolata, Hutton. Plate II, fig. 7.

Scaphula (?) *lanceolata*, Hutton, Trans. N.Z. Inst., xviii, 1885, p. 332. *Poroleda lanceolata*, Hutton, Macleay Memorial Vol., 1893, p. 86 (not *Poroleda lanceolata*, Tate, Proc. Roy. Soc. N.S.W., xxvii. 1894, p. 186 = *Poroleda tatei*, Hedley, "Victorian Naturalist," xxi, Dec. 1904, p. 112).

The name of this species is involved in some confusion. Professor Tate, in March, 1894, introduced a new species, type of a new genus, under the title of *Poroleda lanceolata*. But in the previous September Captain Hutton had redescribed his fossil under the same name. Since *Poroleda lanceolata* was in current use for both the New Zealand and the Australian shell, I have proposed to distinguish that which Tate figured and described from the Gellibrand River beds of Victoria as *Poroleda tatei*.

In colour, texture, and all particulars save those of the hinge-teeth this species closely resembles *Leda ensicula*, Angas, *L. lefroyi*, Beddome, and *L. huttoni*, Tate. These five species might suitably be included in *Poroleda*.

Hitherto *P. lanceolata* has been known only as a Tertiary fossil. Mr. A. Hamilton has shown me a broken valve from off Anchor Island, Dusky Sound. In our 110 fathoms dredging it occurred plentifully. The size of the specimen drawn is—height, 3·85 mm.; length, 13·8 mm.; breadth of single valve, 0·9 mm.

Malletia australis, Quoy and Gaimard.

Solenella australis, Quoy and Gaimard, Voy. "Astrolabe," Zool., iii, 1835, p. 471, pl. 78, f. 5–10.

A single valve.

Bathyarca cybaea, n. sp. Plate I, figs. 3, 4.

Shell small, oblong, short and inflated, inequivalve, a little inequilateral without impressed ray, posteriorly and anteriorly rounded, sinuate beneath the beak. Colour white, probably bleached. Sculpture finely reticulate. A series of delicate subequal evenly spaced riblets radiate from the umbo to the margin; as growth proceeds new riblets are intercalated till about fifty reach the margin. The radii are broken into short lengths by concentric growth-lines which produce minute prickles at the point of intersection. Beak much inrolled, at a third of the length of the shell. Ligamental area narrow.

Hinge-plate edentulous under the beaks, posteriorly with four nearly horizontal, anteriorly with four highly inclined small teeth. Interior rayed by imprint of external sculpture. Margin finely crenulate within except at byssal gape. Length, 3 mm.; height, 2·15 mm.; depth of single valve, 1 mm.

This species, represented by numerous specimens, is nearest allied to the Australian *B. perversidens*, from which it differs by the less development of the posterior side.

Pleurodon maorianus, Hedley.

Pleurodon maorianus, Hedley. "Records of the Australian Museum," v., 1904, p. 87, fig. 14.

This species appeared in profusion.

Dacrydium pelseneeri, n. sp. Plate II, fig. 8.

Shell small, thin, translucid with a nacreous lustre, oblong inflated, straight on the anterior side, rounded dorsally and ventrally, almost angled at the anterior dorsal corner. Umbo slightly projecting. A thin membranous epidermis clothes the valve. Sculpture regular-spaced elevated growth-lines. Hinge with a few anterior teeth, and a long row of posterior teeth which increase in size as they recede from the chondrophore. Height, 2·2 mm.; length, 1·48 mm.

A pair of valves.

The above is the third species recorded from the Southern Hemisphere. *D. albidum* was described by Pelseneer (Result Voy. "Belgica," Moll., 1903, p. 27, pl. viii, f. 10) from 200 fathoms in the South Pacific, near the Antarctic ice-barrier. *D. fabale* was described by myself (P.L.S.N.S.W., xxix, 1904, p. 199, pl. x, f. 39) from 100 fathoms off Wollongong, N.S.W. From Marion Island E. A. Smith has published *Dacrydium meridionalis*, but Bernard has shown (Journ. de Conch., xlv, 1897, p. 8) that this is probably a *Philobrya*.

The novelty appears to differ from *D. albidum* by its rough surface and by its greater length in proportion to height. From its nearer ally *D. fabale* it differs by the straight edge of the anterior margin, and by being smaller and proportionally shorter.

Cochlodesma angasi, Crosse and Fischer.

Periploma angasi, Crosse and Fischer, Journ. de Conch., 1864, p. 349; 1865, p. 427, pl. xi, f. 1.

A single valve.

Verticordia rhomboidea, n. sp. Plate II, figs. 12, 13, 14.

Shell inflated, subrhomboidal, inequilateral, right valve slightly clasping over the left along the dorsal margin, substance very brittle, easily flaking off. Umbos incurved, rather distant, usually eroded. Lunule slightly excavated, dorsal area defined by the radial ribs. Sculpture, no incremental growth-lines, about twenty-two prominent sharp radial ribs which strongly denticulate the margin and imprint the nacreous interior; the surface has everywhere close-set grains which develop minute sharp prickles. Right valve with a large conical tooth under the lunule, and a posterior lateral beneath the dorsal area. Left valve with a minute tooth under the umbo and no lateral; ossicle not found. Height, 5 mm.; length, 5·75 mm.

Several specimens were taken.

The species apparently belongs to the subgenus *Haliris*, Dall. The genus, which is an acquisition to New Zealand, rarely occurs so high in the bathymetrical scale. Fischer proposed (Man. Conch., p. 188) the term "verticordia zone" for the upper half of the abyssal region.

Cuspidaria trailli, Hutton. Plate II, figs. 9, 10, 11.

Neæra trailli, Hutton, Cat. Marine Mollusca of New Zealand, 1873, p. 62.

One small and several broken shells were dredged. I have derived a figure from a specimen, 15 mm. in length, taken by Mr. A. Hamilton in Dusky Sound.

Cuna delta, Tate and May.

Carditella delta, Tate and May, Trans. Roy. Soc. S.A., xxiv, 1900, p. 102. *Cuna delta*, Hedley, Mem. Austr. Mus., iv, 1902, p. 316.

Four separate valves.

Venericardia lutea, Hutton. Plate I, fig. 6.

Cardita lutea, Hutton, Man. N.Z. Mollusca, 1880, p. 159.

The history of this species is complicated. Hutton applied his name to the shell introduced by Deshayes (P.Z.S., 1852 (1854), p. 101) as *Cardita zealandica*, because that clashed with *Venericardia zealandica*, Potiez and Michaud (Gal. des Moll., ii, 1844, p. 166). Glancing aside, I might here remark that the latter species appears to have been misunderstood by all writers on the New Zealand Mollusca, and that the description of Potiez and Michaud is evidently meant for *Chione stutchburyi*, Gray. Finally, Hutton united (P.L.S.N.S.W., ix, 1884, p. 527) his *C. lutea* to the Chilian *Cardita compressa*, Reeve. This identification I am unable to support.

The species was a common one where we dredged. An example selected for figuring is 7 mm. long and 8 mm. high.

Divaricella cumingii, A. Adams and Angas.

Lucina cumingii, Ad. and Angas, Proc. Zool. Soc., 1863, p. 426, pl. xxxvii, f. 20.

Two odd valves.

Loripes concinna, Hutton.

Loripes concinna, Hutton, Trans. N.Z. Inst., xvii, 1884 (1885), p. 323; xviii, p. 363. *Id.,* "Macleay Memorial Volume," 1893, p. 83, pl. ix, f. 90.

Three separate valves of this species were found. It has hitherto only been known as a Pliocene fossil. I am indebted to Mr. Murdoch for the identification.

Thyasira flexuosa, Montagu.

Tellina flexuosa, Montagu, Test. Brit., 1803, p. 72. *Lucina flexuosa,* Woodward's Manual, pl. xix, f. 7.

A few separate valves were obtained. The species has not before been reported from New Zealand, but Mr. Suter informs me that it was noted as *Cryptodon* sp. by Captain Hutton in the Cat. Mar. Moll. N.Z., 1873, p. 75, and that it is in the Colonial Museum from Waikanae Beach.

In the selection of the generic name I have followed Dr. Dall (Trans. Wagner Free Inst., iii, 1903, p. 1335).

Neolepton antipodum, Filhol. Plate I, fig. 5.

Kellya antipodum, Filhol, Compt. Rend. Acad. Sci., xci, 1880, p. 1095. *Neolepton antipodum,* Bernard, Bull. Mus. d'Hist. Nat., vii, 1897, p. 314.

This species was represented by numerous separate valves. It has also occurred to us in 100 fathoms outside Port Chalmers, and was taken by Mr. A. Hamilton in Foveaux Strait. It has not yet been recognised by local workers. The individual illustrated is 1·9 mm. high and 2·1 mm. long.

This opportunity is taken of adding that *Kellya suborbicularis,* Montagu, should replace *Kellya cycladiformis,* Desh., of the Index Faun. Nov.-Zealand., p. 91.

Erycina parva, Deshayes.

Kellia parva, Desh., Pro. Zool. Soc., 1855, p. 182. *Id.,* Tryon, Proc. Acad. Nat. Sci. Philadelphia, (2), iii, 1872. p. 231. *Erycina acupuncta,* Hedley, Mem. Austr. Mus., iv, 1902, p. 321, fig. 60.

The species appears to be more common in New Zealand than in Australia. Mr. R. Murdoch suggested their identity to me. Comparing the few separate valves by which the species is known in Australia, I find that the New Zealand specimens are larger, being 3·6 mm. in length and 2·27 mm. in height, more solid, and with stronger concentric sulci. I believe the two to be variants of one species.

The New Zealand shell was named for me by Mr. H. Suter, for whom in turn it was determined by Dr. W. H. Dall, probably from co-types distributed by Hugh Cuming. The occurrence of the species in space and literature induces me to suspect an error parallel to that of *Leda fastidiosa*, and to conjecture that it did not come from the Philippines, but that it was originally dredged in New Zealand waters by F. Strange during the cruise of H.M.S. "Acheron" in 1849.

It has been detected by Mr. R. Murdoch in the Tertiary beds of Wanganui.

Cardium pulchellum, Gray.

Cardium pulchellum, Gray, Dieffenbach's New Zealand, ii, 1843, p. 252. *Id.*, Reeve, Conch. Icon., ii, 1844, pl. viii, fig. 42.

Single and broken valves were dredged in plenty.

Mactra scalpellum, Reeve.

Mactra scalpellum, Reeve, Conch. Icon., viii, *Mactra*, pl. xix, fig. 106, May, 1854. *Id.*, Deshayes, Proc. Zool. Soc., 1854, p. 65, Feb. 10, 1855.

Several odd valves.

The species should be credited to Reeve, not, as is usual, to Deshayes, for the publication by Reeve was earlier by nearly a year.

Corbula zelandica, Quoy and Gaimard.

Corbula zelandica, Quoy and Gaimard, Voy. "Astrolabe," Zool., iii, 1835, p. 511, pl. 85, figs. 12–14.

A single valve. The type of the species was obtained in the Hauraki Gulf near by.

C. erythrodon, Lamk., is a much larger shell, differing in form and colour. It has been recognised by Lischke (Jap. Meers Conch., i, 1869, p. 136) as a Japanese species, and ought, I think, to be struck off the New Zealand list.

Pteropoda.

This group is included here for convenience. As Pelseneer has demonstrated, they properly belong to Gastropoda.

Cavolinia tridentata, Forskål.

Anomia tridentata, Forskål, Descrip. Anim., 1773, p. 124. *Cavolinia tridentata*, Pelseneer, Chall. Rep., Zool., xxiii. 1888, p. 83.

A few specimens.

This species is an addition to the New Zealand fauna.

Cavolinia trispinosa, Lesueur.

Hyalœa trispinosa, Lesueur, Dict. Sci. Nat., xxii, 1821, p. 82. *Cavolinia trispinosa*, Pelseneer, Chall. Rep., Zool., xxiii, 1888, p. 76.

A few specimens.

Cavolinia inflexa, Lesueur.

Hyalœa inflexa, Lesueur, Nouv. Bull. Soc. Philom., iii, 1813, p. 285, pl. v, fig. 3. *Cavolinia inflexa*, Pelseneer, Chall. Rep., Zool., xxiii, 1888, p. 85.

A couple of specimens.

Cavolinia, sp.

A variation or ally of *C. longirostris* is present, but the specimens are not suitable for description. I have taken this species off the Australian coast, and expect to present an account of it shortly.

Cuvierina columnella, Rang.

Cuvieria columnella, Rang., Ann. Sci. Nat., xiii, 1827, p. 323, p. xlv, f. 1–3. *Cuvierina columnella*, Pelseneer, Chall. Rep. Zool., xxiii, 1888, p. 84.

A single specimen, which adds a genus as well as a species to the fauna of New Zealand.

It may be here noticed that *Cymbulia parvidentata*, Pelseneer (Chall. Rep., Zool., xxiii, 1888, p. 99, pl. ii, f. 12, 13) has been overlooked by the compilers of the "Index Faunæ Novæ-Zealandiæ."

HETEROPODA.

Atlanta, sp.

Fragments of *Atlanta*, a genus not recorded from New Zealand, are present, but are too imperfect for specific determination.

EXPLANATION OF PLATES I AND II.

PLATE I.

Figs. 1, 2. Different aspects and magnified sculpture of *Leda fastidiosa*, A. Adams.
Figs. 3, 4. Interior and exterior of *Bathyarca cybæa*, Hedley.
Fig. 5. Exterior and hinge of *Neolepton antipodum*, Filhol.
Fig. 6. Exterior of *Venericardia lutea*, Hutton.

PLATE II

Fig. 7. Hinge and interior of *Poroleda lanceolata*, Hutton.
Fig. 8. Interior of *Dacrydium pelseneeri*, Hedley.
Figs. 9, 10, 11. Various aspects of *Cuspidaria trailli*, Hutton.
Figs. 12, 13, 14. Various aspects and magnified sculpture of *Verticordia rhomboidea*, Hedley.

ART. XVII.—*On some* Foraminifera *and* Ostracoda *obtained off Great Barrier Island, New Zealand.*

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[*Read before the Wellington Philosophical Society, 2nd August, 1905.*]

Plate III.

INTRODUCTORY REMARKS.

THE following series of *Foraminifera* and *Ostracoda* was obtained from material collected during the dredging operations carried out by Messrs. Hedley and Suter, under the auspices of the Australasian Association for the Advancement of Science, at the Dunedin meeting in 1904.

The sounding from which the microzoa were selected was taken in lat. 36° 8′ S., long. 175° 55′ E., off Great Barrier Island, North Island New Zealand, at a depth of 110 fathoms. This locality is not far from the "Challenger" station 169, where at a depth of 100 fathoms the water had a temperature of 55·2°.* At this station, at a depth of 700 fathoms, sixty-six species of *Foraminifera*, but no *Ostracoda*, were recorded. Of the *Foraminifera*, twenty-eight species are common to both localities, after making allowance for changes in some of the specific names of the earlier record. The *Ostracoda* are dealt with in detail in the sequel to this paper.

The sounding off Great Barrier Island is remarkable for the extraordinary abundance of specimens of *Biloculina*, *Nodosaria*, *Cristellaria*, and *Truncatulina*, and their full development is indicative of especially favourable conditions of life in that particular area.

Another interesting feature of the present assemblage of *Foraminifera* is the presence of a large number of forms which have hitherto been found in dredgings from other, widely removed, areas, generally in the Northern Hemisphere; and particularly from the colder waters of the Temperate Zone.

The following is a list of the *Foraminifera* embodied in this report; the species new to the New Zealand area, according to the list given in Captain Hutton's "Index Faunæ Novæ-Zealandiæ," being marked with an asterisk. Of the 103 species of *Foraminifera* enumerated, fifty-seven are new to this area, whilst one is new to science, and constitutes the type of a new genus.

**Biloculina pisum*, Schlumberger.
**B. anomala*, Schlum.

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* Chall. Reports, Summary of Results, pt. i, 1895, p. 605.

**Miliolina insignis*, H. B. Brady.
M. circularis, Born. sp.
M. seminulum, Linné sp.
**M. vulgaris*, d'Orb. sp.
M. bicornis, W. and J. sp.
**M. agglutinans*, d'Orb. sp.
Planispirina sphæra, d'Orb. sp. (*Biloculina* in "Index").
Pelosina cylindrica, Brady.
P. variabilis, Brady.
P. rotundata, Brady.
**Brachysiphon corbuliformis*, gen. et sp. nov.
Reophax scorpiurus, Montfort sp.
Haplophragmium canariense, d'Orb. sp.
H. globigeriniforme, P. and J. sp.
**H. calcareum*, Brady.
Ammodiscus tenuis, Reuss.
**Textularia conica*, d'Orb.
**T. inconspicua*, Brady.
**T. trochus*, d'Orb.
**T. turris*, d'Orb.
**T. gramen*, d'Orb.
T. gibbosa, var *tuberosa*, d'Orb. (*T. aspera* in "Index").
Spiroplecta sagittula. Defr. sp. (*Textularia* in "Index").
**S. sagittula*, var. *fistulosa*, Brady.
Clavulina communis, d'Orb.
**C. rudis*, Costa sp.
**C. soldanii*, J. and P. sp.
Bulimina pyrula, d'Orb.
**B. pyrula*, var. *spinescens*, Brady.
**B. marginata*, d'Orb.
B. inflata, Seguenza.
Virgulina subsquamosa, Egger.
**Bolivina robusta*, Brady.
**B. karreriana*, Brady.
**Cassidulina lævigata*, d'Orb.
C. subglobosa, Brady.
**C. bradyi*, J. Wright.
**Lagena elongata*, Ehrenb. sp.
**L. gracillima*, Seg. sp.
L. striata, d'Orb. sp.
**L. sulcata*, W. and J. sp.
L. hispida, Reuss.
L. hexagona, Williamson sp.
**L. lacunata*, Burrows and Holland.
**Nodosaria hispida*, d'Orb.
**N. pyrula*, d'Orb.
**N. (D.) consobrina*, d'Orb. sp.
**N. (D.) consobrina*, var. *emaciata*, Reuss.

**N. (D.) filiformis*, d'Orb.
**N. (D.) farcimen*, Reuss sp.
N. (D.) soluta, Reuss sp.
**N. (D.) pauperata*, d'Orb. sp.
**N. (D.) roemeri*, Neug. sp.
N. (D.) obliqua, Linné sp.
**N. (D.) obliqua*, var. *vertebralis*, Batsch var.
**Frondicularia reussi*, Karrer.
**Marginulina glabra*, d'Orb.
**Cristellaria tenuis*, Born. sp.
C. reniformis, d'Orb.
**C. schloenbachi*, Reuss.
**C. tricarinella*, Reuss.
**C. italica*, Defr. sp.
**C. latifrons*, Brady.
**C. articulata*, Reuss sp.
C. rotulata, Lam. sp.
**C. orbicularis*, d'Orb. sp.
C. cultrata, Montf. sp.
**C. mamilligera*, Karrer.
**C. costata*, F. and M. sp.
Uvigerina asperula, Cz.
**U. pygmæa*, d'Orb.
Ramulina globulifera, Brady (not noted in "Index," but recorded by Brady west of New Zealand).
**R. lævis*, Jones.
Globigerina bulloides, d'Orb.
G. triloba, Reuss.
G. inflata, d'Orb.
G. æquilateralis, Brady.
Orbulina universa, d'Orb.
Sphæroidina bulloides, d'Orb.
Pullenia sphæroides, d'Orb. sp.
P. quinqueloba, Reuss sp.
**Truncatulina tenuimargo*, Brady.
**T. reticulata*, Cz. sp.
T. wuellerstorfi, Schwager sp.
T. lobatula, W. and J. sp.
**T. variabilis*, d'Orb.
**T. ungeriana*, d'Orb. sp.
T. akneriana, d'Orb. sp.
T. pygmæa, Hantken.
**T. haidingeri*, d'Orb. sp.
**T. (?) præcincta*, Karrer sp.
**Anomalina polymorpha*, Costa.
Pulvinulina truncatulinoides, d'Orb. sp. (in "Index" as *micheliniana*).
P. crassa, d'Orb. sp.

P. canariensis, d'Orb. sp.
**P. auricula*, F. and M. sp.
**P. schreibersii*, d'Orb. sp.
Rotalia soldanii, d'Orb.
**R. papillosa*, var. *compressiuscula*, Brady.
R. clathrata, Brady.
Nonionina umbilicatula, Montagu sp.

References given below are restricted to the original records and one or two of the more important of later date.

Order FORAMINIFERA.

Family MILIOLIDÆ.

Subfamily Miliolininæ.

Genus **Biloculina**, d'Orbigny.

Biloculina pisum, Schlumberger.

Biloculina pisum, Schlumberger, 1891, Mém. Soc. Zool. France, vol. iv, p. 569, pl. xi, figs. 81–83; text-figure 31.

This species is hardly distinguishable in external appearance from the nearly allied *B. vespertilio*, Schlumberger,* and *B. bradii*, Schl.†; the shape of the aperture being one of the characters which separate it. Upon slicing the tests, however, the identity of our specimens with the above, *B. pisum*, is at once apparent, since the internal arrangement of the chambers in their relation to one another, especially at the point of incurvation and fusion to the previous chamber-wall, is characteristic of this species and *B. comata*, Brady.‡ The latter species is distinguished by its externally striated shell-surface; the arrangement of the initial series of chambers is also different, and the wall of the first chamber in *B. comata* (form A) is thick, whilst in *B. pisum* (form A) it is very thin.

The original locality given by Schlumberger for *B. pisum* is the Mediterranean.

Although this form is quite common in the present series, the tests all appear to belong to the megalospheric type of shell (form A), as Schlumberger also found.

Biloculina anomala, Schlumberger.

Biloculina anomala, Schlumberger, 1891, Mém. Soc. Zool. France, vol. iv, p. 569, pl. xi, figs. 84–86; pl. xii, fig. 101; text-figures 32–34.

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* *Op. supra cit.*, p. 561.
† *Op. supra cit.*, p. 557.
‡ Rep. Chall., vol. ix, 1884, p. 144, pl. iii, figs. 9 *a*, *b*.

This species was found by Schlumberger in dredgings from the Mediterranean, at a depth of 555 meters. A solitary specimen, agreeing in all external characters with the above, is found in our series.

Genus **Miliolina**, Williamson.

Miliolina insignis, Brady.

Miliolina insignis, Brady, 1884, Rep. Chall., vol. ix, p. 165, pl. iv, figs. 8, 10.

This species is fairly common in the present series. It attains the unusual length of 3 mm.

M. insignis has a wide distribution and a great range in depth. One of the localities in which it has previously been found is Bass Strait, 150 fathoms.

Miliolina circularis, Bornemann sp.

Triloculina circularis, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii, p. 349, pl. xix, fig. 4.

Miliolina circularis, Born. sp., Millet, 1898, Journ. R. Micr. Soc., p. 499, pl. xi, figs. 1–3.

Only one example of this form occurs in our series, and this is fairly typical. Millett's specimens were obtained from the Malay Archipelago. Egger records it ("Gazelle" Exped.) from two stations off the Australian coast, and the "Challenger" obtained it in Bass Strait.

Miliolina seminulum, Linné sp.

Serpula seminulum, Linné, 1767, Syst. Nat., 12th ed., p. 1264, No. 791.

Miliolina seminulum, Linné sp., Brady, 1884, Rep. Chall., vol. ix, p. 157, pl. v, figs. 6 *a–c*.

One small but otherwise typical example of this widely distributed form occurs in our series.

Miliolina vulgaris, d'Orbigny sp.

Quinqueloculina vulgaris, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 302, No. 33.

Q. vulgaris, d'Orb., Schlumberger, 1893, Mém. Soc. Géol. France, vol. vi, p. 207, pl. ii, figs. 65, 66; woodcuts, figs. 13, 14.

As a recent species this is usually recorded under the name of *Miliolina auberiana*, d'Orb sp. Its nearest geographical occurrence to the present one is in the Malay Archipelago, where it was found by Millett. It is also an abundant form in the Tertiary deposits of Australia. In the present series it is not uncommon.

Miliolina bicornis, Walker and Jacob sp.

Serpula bicornis, Walker and Jacob, 1798, Adams Essays, Kanmacher's ed., p. 633, pl. xiv, fig. 2.

Miliolina bicornis, W. and J. sp., Goës, 1894, K. Svenska Vet.-Akad. Handlingar, vol. xxv, p. 113, pl. xxi, figs. 860, 861.

Occasional examples of the above species were met with in the present material. It is a widely distributed form, and is most abundant in quite shallow water, the depth at which the present soundings were taken, 110 fathoms, being near the deepest limit of its occurrence.

Miliolina agglutinans, d'Orbigny sp.

Quinqueloculina agglutinans, d'Orbigny, 1839, Foram. Cuba, p. 168, pl. xii, figs. 11–13.

Miliolina agglutinans, d'Orb. sp., Goës, 1894, K. Svenska Vet.-Akad. Handl., vol. xxv, p. 110, pl. xix, fig. 848, and plate xx, fig. 849.

Only one typical example of this widely distributed species occurred in this series.

Subfamily Hauerininæ.

Genus **Planispirina**, Seguenza.

Planispirina sphæra, d'Orbigny sp.

Plate III, figs. 1 *a*, *b*.

Biloculina sphæra, d'Orbigny, 1839, Foram. Amér. Mérid., p. 66, pl. viii, figs. 13–16. Brady, 1884, Rep. Chall., vol. ix, p. 141, pl. ii, figs. 4 *a*, *b*.

Planispirina sphæra, d'Orb. sp., Schlumberger, 1891, Mém. Soc. Zool. France, vol. iv, p. 577, text-figures 45, 46.

The examples in the present collection all show the normal V-shaped aperture, with one exception; this is of larger dimensions, and has a labyrinthic orifice (see figure). The smaller specimens have diameters ranging from 0·425 mm. to 0·8 mm., whilst the specimen with a labyrinthic aperture has a diameter of 1·4 mm.

This species, although never very abundant, is well distributed both as to geographical range and depth. It has already been recorded from this locality at station 169 ("Challenger").

Family ASTRORHIZIDÆ.

Subfamily Astrorhizinæ.

Genus **Pelosina**, Brady.

Pelosina cylindrica, Brady.

Pelosina cylindrica, Brady, 1884, Rep. Chall., vol. ix, p. 236, pl. xxvi, figs. 1–6.

The occurrence of this species at a depth of only 110 fathoms is interesting, since in the "Challenger" dredgings it was an essentially deep-water form; the least depth at which it was found was 620 fathoms. It was also recorded from the "Challenger" station 169, in 700 fathoms. The "Gazelle" expedition obtained this species, however, at 82–86 meters (44 to 47 fathoms), from Western Australia.

Our specimens are typical, and of the normal size. The walls of the test are formed of a fine grey calcareous mud. Somewhat common.

Pelosina variabilis, Brady.

Pelosina variabilis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix, n.s., p. 30, pl. iii, figs. 1–3.

This interesting form is rare in our series. It was found in the "Challenger" dredgings at station 169, near to the present locality, at a depth of 700 fathoms.

Pelosina rotundata, Brady.

Pelosina rotundata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix, n.s., p. 31, pl. iii, figs. 4, 5.

The specimens found in our samples are not so evenly shaped as usual, but there seems to be no doubt of their identity with the above species.

The "Challenger" soundings from near this locality have yielded the same species at a depth of 700 fathoms.

Subfamily Rhabdammininæ.

Genus **Brachysiphon**, gen. nov.

(Deriv.—*βραχύς*, short; *σίφων*, a tube).

Generic Characters.—Test tubular, short, open at both ends or closed at one; consisting of an inner chitinous tube incrusted with sand-grains or small foraminiferal tests, as *Globigerina*, in the only species at present known. Aperture more or less circular, bordered by the thickened chitinous lining of the interior.

Brachysiphon corbuliformis, sp. nov.

Plate III. figs. 2 *a, b*, 3.

Description.—Test roughly cylindrical, short; orally depressed, also basally when double-apertured; irregular in outline; composed of sand-grains and tests of other *Foraminifera*, as *Globigerina*, cemented to a brown chitinous base or internal lining. Aperture more or less circular.

Dimensions.—About 0·8 mm. in diameter. Aperture about 0·28 mm. across.

This species reminds one of *Proteonina difflugiformis*, Brady sp., var. *testacea*, Flint,* in its general appearance. It differs morphologically, however, in having a cylindrical cavity instead of an inflated chamber.

Rather common. Off Great Barrier Island, New Zealand, 110 fathoms.

Family LITUOLIDÆ.

Subfamily LITUOLINÆ.

Genus **Reophax,** Montfort.

Reophax scorpiurus, Montfort sp.

Reophax scorpiurus, Montfort. 1808. Conchyl. Systém., vol. i, p. 330, 83e genre. Brady, 1884, Rep. Chall., vol. ix, p. 291, pl. xxx, figs. 12–17.

Only two specimens of this widely distributed form occur in our series. The test, in each example, is formed of loosely cemented sand-grains. One specimen has a blunt termination, whilst the other gradually tapers to a point.

Genus **Haplophragmium,** Reuss.

Haplophragmium canariense, d'Orbigny sp.

Nonionina canariensis, d'Orbigny, 1839, Foram. Canaries, p. 228, pl. ii, figs. 33, 34.

Haplophragmium canariense, Brady, 1884, Rep. Chall , vol. ix, p. 310, pl. xxxv, figs. 1–5.

Several very fine and typical specimens occur in this dredging. Their tests are of a yellow to a ruddy-brown colour, and their texture somewhat coarsely arenaceous. It is a widely distributed form in recent deposits.

Haplophragmium globigeriniforme, Parker and Jones sp.

Lituola nautiloidea, var. *globigeriniformis*, Parker and Jones, 1865, Phil. Trans., vol clv, p. 407, pl. xv, figs. 46, 47.

Haplophragmium globigeriniforme, P. and J. sp., Brady, 1884, Rep. Chall., vol. ix, p. 312, pl. xxxv, figs. 10, 11.

* Rep. U.S. Nat. Mus. for 1897 (1899), p. 273, pl. xvi, fig. 1.

Brady regards this species as essentially of deep-water habitat, and it is consequently not surprising to find it but rarely in the sounding off Great Barrier Island. One of the specimens was accidentally broken, and showed the test to be very thin, and formed of almost uniform sand-grains very neatly cemented, and having a smooth surface both on the interior and exterior. In our specimen the chambers increase very rapidly in size with growth.

H. globigeriniforme has been recorded from the "Challenger" sta. 169, at 700 fathoms.

Haplophragmium calcareum, Brady.

Haplophragmium calcareum, Brady, 1884, Rep. Chall., vol. ix, p. 302, pl. xxxiii, figs. 5–12.

A typical specimen occurs in our series. It is almost entirely a tropical species, an exception occurring, in the "Challenger" records, off Sydney, 410 fathoms.

Subfamily Trochammininæ.

Genus **Ammodiscus,** Reuss.

Ammodiscus tenuis, Brady.

Ammodiscus tenuis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi, n.s., p. 51. *Id.*, 1884, Rep. Chall., vol. ix, p. 332, pl. xxxviii, figs. 4–6.

The form distinguished as *A. tenuis* occurs with some frequency in our sounding. It has been previously recorded,* in company with *A. incertus*, d'Orb., from a neighbouring locality—station 169; and Dr. Brady, indeed, threw out the suggestion that the form was perhaps only a local variety of the better-known and ubiquitous species *A. incertus*.

Dr. Rhumbler has also remarked about this species,† "Die Scheibe ist dünner, die welcher sie vielleicht die megalosphärische Form darstellt."

A general examination of our specimens showed the initial portion of the coil in every case to commence with a more or less swollen "protoconch" or (?) megalosphere. This is subject to much variation in size, which at first seemed to lend support to the idea that a microsphere might be present in *A. tenuis*. To conclusively settle this doubtful point, however, it will necessitate the examination of a further series of specimens.

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* Rep. Chall., Summary of Results, vol. i, 1895, p. 605.

† Archiv für Protistenkunde, vol. iii, 1903, p. 281.

The initial portion of the shell is subspheroidal, and seems to be merely an inflation of the tubular part of the shell. The dimensions of some of the initial chambers in their longest diameter are as follows: Specimens figured by Brady—360μ and 300μ. From the present series—100μ, 75μ, 50μ.

Family TEXTULARIIDÆ.

Subfamily TEXTULARIINÆ.

Genus **Textularia**, Defrance.

Textularia conica, d'Orbigny.

Textularia conica, d'Orbigny, 1839, Foram. Cuba, p. 135, pl. i, figs. 19, 20. Brady, 1884, Rep. Chall., vol. ix, p. 365, pl. xliii, figs. 13, 14; pl. cxiii, figs. 1 *a*, *b*.

One characteristic specimen.

Textularia inconspicua, Brady.

Textularia inconspicua, Brady, 1884, Rep. Chall., vol. ix, p. 357, pl. xlii, fig. 6. Millett, 1899, Journ. R. Micr. Soc., p. 557, pl. vii, fig. 1.

One specimen of this elegant little form occurs in the present series. The localities previously recorded for this species are—off East Moncœur Island, Bass Strait; Nares Harbour, Admiralty Islands; the *Hyalonema* ground, south of Japan; and the Malay Archipelago.

Textularia trochus, d'Orbigny.

Textularia trochus. d'Orbigny, 1840, Mém. Soc. Géol. France, vol. iv, p. 45, pl. iv, figs. 25, 26. Brady, 1884, Rep. Chall., vol. ix, p. 366, pl. xliii, figs 15–19; pl. xliv, figs. 1–3. Egger, 1893, Abhandl. k. bayer. Akad. Wiss., cl. ii, vol. xviii. p. 273, pl. vi, figs. 37, 38.

Two fairly well grown specimens occur in the present series, having non-limbate sutures.

Textularia turris, d'Orbigny.

Textularia turris, d'Orbigny, 1840, Mém. Soc. Géol. France, vol. iv, p. 46, pl. iv, figs. 27, 28. Brady, 1884, Rep. Chall., vol. ix, p. 366, pl. xliv, figs. 4, 5.

It is interesting to meet with this species off Great Barrier Island, since it is rare in the recent condition. It has only been observed previously off Culebra Island, 390 fathoms, and off the coast of South America, south-east of Pernambuco, 350 fathoms.

Textularia gramen, d'Orbigny.

Textularia gramen, d'Orbigny, 1846, Foram. Foss. Vienne. p. 248, plate xv, figs. 4–6. Egger, 1893, Abhandl. k. bayer. Akad. Wiss., cl. ii, vol. xviii, p. 272, pl. vi, figs. 24–26.

Two characteristic specimens of this well-distributed form occur in our series.

Textularia gibbosa, var. **tuberosa,** d'Orbigny.

Textularia tuberosa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 263, No. 26.

T. aspera, Brady, 1882, Proc. R. Soc. Edin., vol. xi, p. 715. *Id.*, 1884, Rep. Chall., vol. ix, p. 367, pl. xliv, figs. 9–13.

T. gibbosa, forma *tuberosa*, d'Orbigny, Fornasini, 1903, Mem. Acc. Sci. Ist. Bologna, ser. v, vol. x, p. 300, pl. O, fig. 2.

The recent examples are better known under the name of *T. aspera*, Brady, which is, however, identical in its essential characters with the earlier-described *T. tuberosa*. Our specimens have the ruddy-brown tests similar in colour to the examples found in North Atlantic.

Genus **Spiroplecta,** Ehrenberg.

Spiroplecta sagittula, Defrance sp.

Textularia sagittula, Defrance, 1824, Dict. Sci. Nat., vol. xxxii, p. 177; 1828, vol. liii, p. 344; Atlas Conch., pl. xiii, fig. 5.

Spiroplecta sagittula, Defr. sp., J. Wright, 1891, Proc. R. Irish Acad., p. 471.

This species and the following variety attain to a great length in this deposit, some of the specimens measuring 4 mm. *T. sagittula* was found off the coast of New Zealand (sta. 169) by the "Challenger."

Spiroplecta sagittula, Defr. sp., var. **fistulosa,** Brady.

Plate III, fig. 4.

Textularia sagittula, Defr., var. *fistulosa*, Brady, 1884, Rep. Chall., vol. ix, p. 362, pl. xiii, figs. 19–22.

This variety is much more abundant in the present series than the specific form, and attains approximately the same length.

Genus **Clavulina,** d'Orbigny.

Clavulina communis, d'Orbigny.

Clavulina communis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 268, No. 4. Brady, 1884, Rep. Chall., vol. ix, p. 394, pl. xlviii, figs. 1–13.

This species is not at all common, but typical specimens occur, measuring about 3 mm. in length. It has been already recorded from the Southern Ocean, and is more commonly found in the Southern Hemisphere.

Clavulina rudis, Costa sp.

Glandulina rudis, Costa, 1857, Mem. R. Acc. Sc. Napoli. vol. ii, p. 142, pl. i, fig. 12.

Clavulina cylindrica, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv, p. 18. pl. i, fig. 8.

C. rudis, Costa sp., Fornasini, 1883, Boll. Soc. Geol. Ital., vol. ii, p. 184, pl. ii, fig. 4. A. Silvestri, 1904, Mem. d. Pontif. Accad. Rom. d. Nuovi Lincei, vol. xxii, p. 259, p. 262, text-figs. 8–10.

Several specimens were found. agreeing in all essentials with the forms figured by previous authors.

The "Challenger" discovered this species (recorded as *C. cylindrica* by Brady) on the west coast of New Zealand, at 275 fathoms.

Clavulina soldanii, Jones and Parker sp.

Lituola soldanii, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi, p. 307, No. 184.

Haplostiche soldanii, J. and P. sp., Brady, 1884, Rep. Chall., vol. ix, p. 318, pl. xxxii, figs. 12–18.

Clavulina soldanii, J. and P. sp., Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix, No. 1, pt. xx, p. 37, pl. iv, figs. 39–46.

Goës has shown that certain slender forms of this species exhibit a definite valvuline aperture, whilst others have a modified labyrinthic opening.

Our specimens clearly display the valvuline character of the aperture.

Not uncommon.

Subfamily Buliminінæ.

Genus **Bulimina**, d'Orbigny.

Bulimina pyrula, d'Orbigny.

Bulimina pyrula, d'Orbigny, 1846, Foram. Foss. Vienne, p. 184, pl. xi, figs. 9, 10. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 290, pl. xxxvi, figs. 4, 5. Millett, 1900, Journ. R. Micr. Soc., p. 275.

Several specimens, with thin glassy tests, occur in the present series.

B. pyrula was also found at station 169 by the "Challenger."

Bulimina pyrula, d'Orbigny, var. **spinescens**, Brady.

Bulimina pyrula, d'Orbigny, var. *spinescens*, Brady, 1884, Rep. Chall., vol. ix, p. 400, pl. l, figs. 11, 12.

Occasional in our series. It has occurred off the coast of Norway (Parker and Jones), and off Ki Islands, Eastern Archipelago, 580 fathoms (Brady).

Bulimina marginata, d'Orbigny.

Bulimina marginata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 269, No. 4, pl. xii, figs. 10–12. Egger, 1893, Abhandl. k. bayer. Akad. Wiss., cl. ii, vol. xviii, p. 287, pl. viii, figs. 69, 70.

This widely distributed form is abundant in the sounding off Great Barrier Island.

Bulimina inflata, Seguenza.

Bulimina inflata, Seguenza, 1862, Atti Accad. Gioenia Sci. Nat., ser. 2, vol. xviii, p. 109, pl. i, fig. 10. Millett, 1900, Journ. R. Micr. Soc., p. 279.

The above species has a somewhat wide distribution. It is rather unusual to find it at a depth of only 100 fathoms, as it is a fairly deep-water species.

A single specimen occurred in our series.

Genus **Virgulina**, d'Orbigny.

Virgulina subsquamosa, Egger.

Virgulina subsquamosa, Egger, 1857, Neues Jahrb. für Min., &c., p. 295, pl. xii, figs. 19–21. Brady, 1884, Rep. Chall., vol. ix, p. 415, pl. lii, figs. 7–11.

This species is rather abundant in the present sounding. It does not appear to have been found before in this locality. It has been recorded, however, from station 165B ("Challenger") between Sydney and New Zealand.

Genus **Bolivina**, d'Orbigny.

Bolivina robusta, Brady.

Bolivina robusta, Brady, 1884, Rep. Chall., vol. ix, p. 421, pl. liii, figs. 7–9. Millett, 1900, Journ. R. Micr. Soc., p. 543.

Our specimens are rather small, but otherwise typical. It is apparently new to this particular area.

Bolivina karreriana, Brady.

Bolivina karreriana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi, n.s., p. 58. *Id.*, 1884, Rep. Chall., vol. ix, p. 424, pl. liii, figs. 19–21. Millett, 1900, Journ. R. Micr. Soc., p. 546.

The finer washings from the sounding off Great Barrier Island have yielded this species in abundance. It is new to the New Zealand area. Among other places recorded are Western Australia by Egger ("Gazelle") at 359 meters, and from the Malay Archipelago by Millett.

Subfamily Cassidulininæ.

Genus **Cassidulina**, d'Orbigny.

Cassidulina lævigata, d'Orbigny.

Cassidulina lævigata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 282 (No. 1), pl. xv, figs. 4, 5; modèle No. 41. A. Silvestri, 1896, Pontif. Accad. Nuovi Lincei, vol. xii, p. 103, pl. ii, fig. 10.

Two specimens were found in our series. The species has a wide distribution, and has been found in the Southern Ocean as far as the Antarctic ice-barrier (Brady).

Cassidulina subglobosa, Brady.

Cassidulina subglobosa, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi, n.s., p. 60. *Id.*, 1884, Rep. Chall., vol. ix, p. 430, pl. liv, figs. 17 *a–c*.

This species has already been recorded from the South Pacific, and also from the Southern Ocean. It is not infrequent in the present collection.

Cassidulina bradyi, J. Wright.

Cassidulina bradyi (Norman MS.), J. Wright, 1880, Proc. Belfast Nat. Field Club, Appendix, p. 152.

C. bradyi, Norman, H. B. Brady, 1884, Rep. Chall., vol. ix, p. 431, pl. liv, figs. 6–10.

This species has always been referred to on the authority of Norman. The first published reference to it, however, was by Joseph Wright, who described it as "a crozier-shaped *Cassidulina*." Several examples of this pretty species occur in our series. It has been found in the South Pacific, but does not seem to have previously occurred near the present locality.

Family LAGENIDÆ.

Subfamily Lageninæ.

Genus **Lagena**, Walker and Boys.

Lagena elongata, Ehrenberg sp.

Miliola elongata, Ehrenberg, 1854, Mikrogeologie, pl. xxv, fig. 1.

Lagena elongata, Ehr. sp., Brady, 1884, Rep. Chall., vol. ix, p. 457, pl. lvi, fig. 29. Millett, 1901, Journ. R. Micr. Soc., p. 492, pl. viii, fig. 10.

One specimen found, slightly curved.

Lagena gracillima, Seguenza sp.

Amphorina gracillima, Seguenza, 1862, Foram. Monotal. Mess., p. 51, pl. i, fig. 37.

Lagena gracillima, Seg. sp., A. Silvestri, 1900, Mem. Pontif. Accad. Nuovi Lincei, vol. xvii, p. 245, pl. vi, fig. 42.

A specimen, resembling an attenuated pear-shaped pipette, occurs in the present series.

Lagena striata, d'Orbigny sp.

Oolina striata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 21, pl. v, fig. 12.

Lagena striata, d'Orb. sp., Goës, 1894, K. Svenska Vet.-Akad. Handl., vol. xxv, p. 75, pl. xiii, figs. 732–736. Millett, 1901, Journ. R. Micr. Soc., p. 487.

A perfect specimen was found in our sounding, showing a faint, oblique annulation of the neck.

Lagena sulcata, Walker and Jacob sp.

Serpula (Lagena) striata sulcata rotundata, Walker and Boys 1784, Test. Min., p. 2, pl. 1, fig 6.

Lagena sulcata, W. and J. sp., Flint, 1899, Rep. U.S. Nat. Mus. for 1897, p. 307, pl. liii, fig. 7. Millett, 1901, Journ. R. Micr. Soc., p. 488.

One specimen was found in our sounding, having thin but not expansive riblets.

Lagena hispida, Reuss.

Lagena hispida, Reuss, 1858, Zeitschr. d. deutsch. geol. Gesellsch., vol. x, p. 434. *Id.*, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi, p. 335, pl. vi, figs. 77–79. Brady, 1884, Rep. Chall., vol. ix, p. 459, pl. lvii, figs. 1–4 ; pl. lix, figs. 2, 5. Flint, 1899 (1897), Rep. U.S. Nat. Mus., p. 307, pl. liii, fig. 8.

A typical specimen, having a slender neck, occurs in our series.

Lagena hexagona, Williamson sp.

Entosolenia squamosa, var. *hexagona*, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i, p. 20, pl. ii, fig. 23.

Lagena hexagona, Williamson sp., Millett, 1901, Journ. R. Micr. Soc., p. 8.

A single typical specimen of this elegant form occurs in our material.

Lagena lacunata, Burrows and Holland.

Lagena lacunata, Burrows and Holland, 1895, in Jones's Palæont. Soc. Mon., Crag. Foram., pt. ii, p. 205, pl. vii, fig. 12.

This species is distinguished from the better-known *L. castrensis*, Schwager, by the depressions on the faces of the test. Millett regards both of these forms, perhaps rightly, as one variety of *L. orbignyana.*

L. lacunata is not uncommon in our soundings.

Subfamily Nodosariinæ.

Genus **Nodosaria,** d'Orbigny.

Nodosaria hispida, d'Orbigny.

Nodosaria hispida, d'Orbigny, 1846, Foram. Foss. Vienne, p. 35, pl. i, figs. 24, 25. Egger, 1899, Abhandl. k. bayer. Akad. Wiss., cl. ii, vol. xxi, p. 79, pl. ix, figs. 23, 24.

This is a very variable form, the only constant character being the hispid surface of the test.

A single specimen was found off Great Barrier Island, which consists of two closely conjoined chambers with short, coarse prickles.

N. hispida has been met with in the South Pacific, but not very near the present locality.

Nodosaria pyrula, d'Orbigny.

Nodosaria pyrula, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 253, No. 13. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 309, pl. lv, fig. 4. Millett, 1902, Journ. R. Micr. Soc., p. 514.

Three specimens of this sparingly distributed form occur in our series. In each case the last chamber of the test is seen to contain a reddish-brown substance which is probably of the nature of dried protoplasm.

N. pyrula has been recorded from various observing-stations in the South Pacific, but not from the present locality.

Subgenus **Dentalina**, d'Orbigny.

Nodosaria (Dentalina) consobrina, d'Orbigny sp.

Dentalina consobrina, d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. ii, figs. 1–3. *Nodosaria (D.) consobrina*, d'Orbigny sp., Brady, 1884, Rep. Chall., vol. ix, p. 501, pl. lxii, figs. 23, 24.

A single specimen was found in our sample.

Nodosaria (D.) consobrina, d'Orb. sp., var. **emaciata**, Reuss.

Dentalina emaciata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 63, pl. iii, fig. 9.

Nodosaria (D.) consobrina, d'Orb. sp., var. *emaciata*, Reuss, Brady, 1884, Rep. Chall., vol. ix, p. 502, pl. lxii, figs. 25, 26.

This slender variety is more common than the type form in the present series. It has already been recorded from the South Pacific.

Nodosaria (D.) filiformis, d'Orbigny.

Plate III, fig. 5.

Nodosaria filiformis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 253, No. 14. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 310, pl. lv, fig. 6.

This species is distinguished by its long, slender, recurved test, with oval segments. It is not uncommon in the present series. Some of the specimens have a bulbous commencement, whilst others have the extremity attenuated and finely pointed. The latter variation agrees with the form figured by d'Orbigny under the name of *Dentalina elegans*.

N. (D.) filiformis has been recorded from the South Pacific, but not from the neighbourhood of Great Barrier Island.

Nodosaria (D.) farcimen, Reuss sp.

Dentalina farcimen, Reuss (after Soldani), 1863, Bull. Acad. Roy. Belg., ser. 2, vol. xv, p. 146, pl. i, fig. 18.

Nodosaria farcimen, Soldani sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 309, pl. lv, fig. 5.

One specimen of this universally distributed form found in our series.

Nodosaria (D.) soluta, Reuss sp.

Dentalina soluta, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii, p. 63, pl. vii, fig. 4.

Nodosaria soluta, Reuss sp., Flint, 1899, Rep U.S. Nat. Mus. (1897), p. 310, pl. lvi, fig. 3. Millett, 1902, Journ. R. Micr. Soc., p. 516.

This species is not uncommon in the present series. Its occurrence at 110 fathoms off Great Barrier Island is in accordance with Dr. Brady's remark that in the South Pacific this species affects shallower water than in other localities. *N. (D.) soluta* has been recorded from the "Challenger" station 169 by Dr. Brady.

Nodosaria (D.) pauperata, d'Orbigny sp.

Dentalina pauperata, d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. i, figs. 57, 58.

Nodosaria (D.) pauperata, d'Orb. sp., Brady, 1884, Rep. Chall., vol. ix, p. 500, woodcuts, figs. 14 *a–c*.

This species is fairly typical, and occurs frequently in our series.

Nodosaria (D.) roemeri, Neugeboren sp.

Dentalina roemeri, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii, p. 82, pl. ii, figs. 13–17.

N. (D.) roemeri, Neug. sp., Brady, 1884, Rep. Chall., vol. ix, p. 505, pl. lxiii, fig. 1.

This form has been recorded by Brady as being chiefly found in the North Atlantic, at depths of less than 1,000 fathoms. It is therefore the more interesting to meet with it in the present sounding off Great Barrier Island at 110 fathoms, where it is not uncommon.

Nodosaria (D.) obliqua, Linné sp.

Nautilus obliquus, Linné, 1767, Syst. Nat., 12th ed., p. 1163, 281; 1788, *Ibid.*, 13th (Gmelin's) ed , p. 3372, No. 14.

Nodosaria (D.) obliqua, Linné sp., Brady, 1884, Rep. Chall., vol. ix, p. 513, pl. lxiv, figs. 20–22. Goës, 1894, K. Svenska Vetenskaps-Akad. Handl., vol. xxv, No. 9, p. 70, pl. xii, figs. 691–696; pl. xiii, fig. 697.

This is one of the most noteworthy species of Foraminifera in the present series, and is here very abundant. It is not uncommon to find specimens reaching the extraordinary length of 9·5 mm. Some of the shells are rather irregular in growth, and tend to become sinuous.

N. (D.) obliqua has been previously recorded from "Challenger" station 169, near the present locality.

Nodosaria (D.) obliqua, L. sp., var. **vertebralis,** Batsch var.

Plate III, fig. 5.

Nautilus (Orthoceras) vertebralis, Batsch, 1791, Conchyl. des Seesandes, p. 3, No. 6, pl. ii, figs. 6 *a*, *b*.

Nodosaria vertebralis, Batsch sp., Brady, 1884, Rep. Chall., vol. ix, p. 514, pl. lxiii, fig. 35; pl. lxiv, figs. 11–14.

N. obliqua, L. sp., var. *vertebralis*. Batsch, Goës, 1894, K. Svenska Vetenskaps-Akad. Handl., vol. xxv, No. 9, p. 70, pl. xiii, figs. 698, 699.

That this form is only a variety of *N. obliqua* is clearly demonstrated by the present series of specimens. Indeed, it is somewhat difficult to satisfactorily separate the variety from the species in some cases.

Genus **Frondicularia**, Defrance.

Frondicularia reussi, Karrer.

Plate III, fig. 7.

Frondicularia reussi, Karrer, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv, p. 441, pl. i, fig. 1.

Three examples of an ovate, striated *Frondicularia* were found off Great Barrier Island. They are almost exactly matched by Karrer's figured specimen, from the Miocene of the Vienna basin. The narrowest of our specimens may also be compared with Karrer's *F. sculpta*, figured on the same plate as the above. These shells are obviously of the same type as the earlier-described *F. annularis* of d'Orbigny,* from the Miocene of Baden; this, however, is a generally broader form.

This appears to be the first occurrence of *F. reussi* in recent deposits.

Genus **Marginulina**, d'Orbigny.

Marginulina glabra, d'Orbigny.

Marginulina glabra, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 259, No. 6; modèle No. 55. Brady, 1884, Rep. Chall., vol. ix, p. 527, pl. lxv, figs. 5, 6. Flint, 1899, Rep. U.S. Nat. Mus. (1879), p. 313, pl. lx, fig. 1. Millett, 1902, Journ. R. Micr. Soc., p. 526.

Two specimens, one short and stout (typical), the other more elongated, were found in our series.

Genus **Cristellaria**, Lamarck.

Cristellaria tenuis, Bornemann sp.

Marginulina tenuis, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii, p. 326, pl. xiii, fig. 14.

Cristellaria tenuis, Born. sp., Brady, 1884, Rep. Chall., vol. ix, p. 535, pl. lxvi, figs. 21–23. Chapman, 1895, Proc. Zool. Soc. Lond., p. 33.

A characteristic example of this elegant little cristellarian was found in our sounding. It has also been recorded from

* Foram. Foss. Vienne, 1846, p. 59, pl. ii, figs. 44–47.

two places off the west coast of New Zealand, at 150 and 275 fathoms (Brady).

Cristellaria reniformis, d'Orbigny.

Cristellaria reniformis, d'Orbigny, 1846, Foram. Foss. Vienne, p. 88, pl. iii, figs. 39, 40. Brady, 1884, Rep. Chall., vol. ix, p. 539, pl. lxx, figs. 3 *a*, *b*. Chapman, 1895, Proc. Zool. Soc. Lond., p. 33. Flint, 1899, Rep. U.S. Nat. Mus. (1897) p. 315, pl. lxii, fig. 2.

A single example was found in the present sounding. This species has been previously recorded from the South Pacific, but is always found sparingly.

Cristellaria schloenbachi, Reuss.

Cristellaria schloenbachi, Reuss, 1862, Sitzungb. d. k. Ak. Wiss. Wien, vol. xlvi, p. 65, pl. vi, figs. 14, 15. Brady, 1884, Rep. Chall., vol. ix, p. 539, pl. lxvii, fig. 7. Millett, 1903, Journ. R. Micr. Soc., p. 253.

One fine example was found in our material.

The nearest recorded localities to the present appear to be Raine Island and the Malay Archipelago.

Cristellaria tricarinella, Reuss.

Cristellaria tricarinella, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi, p. 68, pl. vii, fig. 9; pl. xii, figs. 2–4. Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 159, pl. xii, figs. 28, 29.

This interesting cristellarian is fairly common in the present series. The "Challenger" records are all in the Pacific, one locality being off the west coast of New Zealand, at 150 fathoms. Egger records this species from Mauritius, and off the west coast of Australia ("Gazelle").

Cristellaria italica, Defrance sp.

Saraccnaria italica, Defrance, 1824, Dict. Sci. Nat., vol. xxxii, p. 177; 1827, vol. xlvii, p. 344; Atlas Conch., pl. xiii, fig. 6. *Cristellaria italica*, Defr. sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 316, pl. lxiii, fig. 6. Millett, 1903, Journ. R. Micr. Soc., p. 256.

Several specimens were selected from our sample. It has a rather wide distribution, but it is never very common. It was found at four "Challenger" stations in the South Pacific.

Cristellaria latifrons, Brady.

Cristellaria latifrons, Brady, 1884, Rep. Chall., vol. ix, p. 544, pl. lxviii, fig. 19; pl. cxiii, figs. 11 *a*, *b*. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 316, pl. lxiii, fig. 3.

This handsome species is fairly well represented in our series by some broad but otherwise typical specimens.

C. latifrons was originally recorded by Brady from the "Challenger" station at Culebra Island, West Indies, 390 fathoms, and off the west coast of New Zealand, 275 fathoms. To these localities Flint adds Florida, and Gulf of Mexico, 60 to 210 fathoms.

Cristellaria articulata, Reuss sp.

Robulina articulata, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii, p. 53, pl. v, fig. 62. *Cristellaria articulata*, Reuss sp., Brady, 1884, Rep. Chall., vol. ix, p. 547, pl. lxix, figs. 1–4, 10–12. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 317, pl. lxiv, fig. 2.

It is of much interest to add another locality for this somewhat restricted species. The previous records are Culebra Island, West Indies, 390 fathoms, and off Nightingale Island, Tristan d'Acunha, 100–150 fathoms (Brady); also Gulf of Mexico and off the Coast of Georgia, 169 to 276 fathoms (Flint).

C. articulata is characteristic and fairly common in our sounding off Great Barrier Island. No examples of wild-growing forms such as Dr. Brady describes were met with in the present series.

Cristellaria rotulata, Lamarck sp.

Lenticulites rotulata, Lamarck, 1804, Ann. Mus., vol. v, p. 188, No. 3; and 1806, vol. viii, pl. lxii, fig. 11.

Cristellara rotulata, Lam. sp., Flint. 1899, Rep. U.S. Nat. Mus. (1897), p. 314, pl. lxiv, fig. 4. Millett, 1903, Journ. R. Micr. Soc., p. 257.

This widely distributed species has already been recorded by the "Challenger" from station No. 169, off the east coast of New Zealand. It is not uncommon in our sounding off Great Barrier Island.

Cristellaria orbicularis, d'Orbigny sp.

Robulina orbicularis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 288, pl. xv, figs. 8, 9.

Cristellaria orbicularis, d'Orb. sp., Chapman, 1895, Proc. Zool. Soc. Lond., p. 33. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 317, pl. lxiv, fig. 3.

A single specimen was found in our material. This species has been recorded off Sombrero Island, West Indies; and from the South Pacific—amongst other localities mentioned by Dr. Brady—off the west coast of New Zealand, 150 fathoms; off Sydney, 401 fathoms; and off Moncœur Island, Bass Strait, 38 fathoms. Dr. Flint found this species in the Gulf of Mexico at 210 and 169 fathoms.

Cristellaria cultrata, Montfort sp.

Robulus cultrata, Montfort, 1808, Conchyl. Syst., vol. i, p. 214, 54e genre.

Cristellaria cultrata, Montf. sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 318, pl. lxv, fig. 2.

This species is common and widely distributed. It is somewhat abundant in our material.

Brady remarks of this species that it affects deeper water than the non-carinate *C. rotulata*, and that fine specimens are rarely met with at less than 100 fathoms. *C. cultrata* has been recorded by the "Challenger" from station No. 169, off the east coast of New Zealand.

Cristellaria mamilligera, Karrer.

Cristellaria mamilligera, Karrer, 1864, "Novara," Exped., geol. Theil, vol. i, Palæont., abth. ii, p. 76, pl. xvi, fig. 5. Brady, 1884, Rep. Chall., vol. ix, p. 553, pl lxx, figs. 17, 18.

The previous records of this species as a recent form are by Brady—off Kandavu, Fiji, 210 fathoms, and off the Philippines, 92 fathoms. One well-grown shell occurs in our material from Great Barrier Island.

C. mamilligera was found as a fossil by Dr. Karrer in the Tertiary greensandstone of New Zealand (Orakei Bay), and by C. von Gümbel in the nummulitic marl of the Bavarian Alps.

Cristellaria costata, Fichtel and Moll sp.

Nautilus costatus, Fichtel and Moll, 1798, Test. Micr., p. 47, pl. iv, figs. *g*, *h*, *i*.

Cristellaria costata, F. and M. sp., Brady, 1884, Rep. Chall., vol. ix, p. 555, pl. lxxi, figs. 8, 9. Millett, 1903, Journ. R. Micr. Soc., p. 258.

This is a rare form in recent deposits, the "Challenger" having only recorded it from three stations—at the Canaries, off Kandavu, Fiji, and off Raine Island, Torres Strait. *C. costata* has also been reported from the shores of the Adriatic, and Millett observed it in soundings from the Malay Archipelago. Two specimens were found off Great Barrier Island.

Subfamily POLYMORPHININÆ.

Genus **Uvigerina**, d'Orbigny.

Uvigerina asperula, Czjzek.

Uvigerina asperula, Czjzek, 1848, Haidinger's Naturwiss. Abhandl., vol. ii, p. 146, pl. xiii, figs. 14, 15. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 320, pl. lxviii, fig. 4. Millett, 1903, Journ. R. Micr. Soc., p. 267.

U. asperula has been already recorded from New Zealand at "Challenger" station No. 169. Somewhat common in our sample.

Uvigerina pygmæa, d'Orbigny.

Uvigerina pygmæa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 269, pl. xii, figs. 8, 9; modèle No. 67. Goës, 1894, K. Svenska Vet.-Akad. Handl., vol. xxv. p. 51, pl. ix, figs. 496–501. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 320, pl. lxviii, fig. 2. Millett, 1903, Journ. R. Micr. Soc., p. 269.

Frequent in our sounding, but the specimens are not well developed.

Subfamily RAMULININÆ.

Genus **Ramulina**, Rupert Jones.

Ramulina globulifera, Brady.

Ramulina globulifera, Brady, 1879, Quart. Journ. Micr. Sci., n.s., vol. xix, p. 272, pl. viii, figs. 32, 33. *Id.*, 1884, Rep. Chall., vol. ix, p. 587, pl. lxxvi. figs. 22–28. Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, p. 310, pl. ix, fig. 62. Jones and Chapman, 1897, Journ. Linn. Soc. Lond. (Zool.), vol. xxvi, p. 340, figs. 5–22. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 321, pl. lxviii, fig. 6. Millett, 1903, Journ. R. Micr. Soc., p. 274.

This species has a wide distribution, but is best developed in the Southern Hemisphere. The localities given by Brady are in the North Atlantic, the North Pacific, and the South Pacific (off the west coast of New Zealand at 145 and 275 fathoms, and near the Fiji Islands, and south of New Guinea). Egger has recorded this form from Western Australia, and Millett has lately found it in the Malay Archipelago.

The specimens from our sounding off Great Barrier Island are both numerous and large.

Ramulina lævis, Jones.

Ramulina lævis, Jones (in Wright), 1875, Proc. Belf. Nat. Field Club, 1873–74, append. iii, p. 88, pl. iii, fig. 19. Jones and Chapman, 1897, Journ. Linn. Soc. Lond. (Zool.), vol. xxvi, p. 339, figs. 1–4. Millett, 1903, Journ. R. Micr. Soc., p. 274.

Not so common as the preceding species. Millett records it from the Malay Archipelago.

Family GLOBIGERINIDÆ.

Genus **Globigerina**, d'Orbigny.

Globigerina bulloides, d'Orbigny.

Globigerina bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 277, No. 1; modèles Nos. 17, 76. Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft 14, p. 21, figs. 24–26. Millett, 1903, Journ. R. Micr. Soc., p. 685.

G. bulloides has been previously recorded from the east coast of New Zealand (sta. 169, "Challenger").

In our sample specimens are fairly common, but small.

Globigerina triloba, Reuss.

Globigerina triloba, Reuss, 1849, Denkschr. Ak. Wiss. Wien, vol. i, p. 374, pl. xlvii, fig. 11. Fornasini, 1899, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. vii, p. 581, pl. ii, figs. 9, 10.

G. bulloides, d'Orb., var. *triloba*, Reuss, Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft 14, p. 25.

This occurs in our sample with some frequency The specimens are small.

Globigerina inflata, d'Orbigny.

Globigerina inflata, d'Orbigny, 1839, Foram. Canaries, p. 134, pl. ii, figs. 7–9. Fornasini, 1899, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. vii, p. 577, pl. 1, fig. 3. Rhumbler, 1900, and in K. Brandt's Nordische Plankton, heft 14, p. 19, fig. 19. Millett, 1903, Journ. R. Micr. Soc., p. 687.

This species is rather common in our sounding. It has already been recorded from the east coast of New Zealand ("Challenger" sta. 169).

Globigerina æquilateralis, Brady.

Globigerina æquilateralis, Brady, 1879, Quart. Journ. Micr. Sci., n.s., vol. xix, p. 71. *Id.*, 1884, Rep. Chall., vol. ix, p. 605, pl. lxxx, figs. 18–21. Fornasini, 1899, Mem. R. Accad. Sci. Ist. Bologna, ser. 5, vol. vii, p. 580, pl. iv, figs. 3, 4. Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft 14, p. 20, figs. 21–23. Millett, 1903, Journ. R. Micr. Soc., p. 689.

The above species has been previously recorded from the east coast of New Zealand ("Challenger" sta. 169). It is rare in our series.

Genus **Orbulina,** d'Orbigny.

Orbulina universa, d'Orbigny.

Orbulina universa, d'Orbigny, 1839, Foram. Cuba, p. 3, pl. i, fig. 1. Rhumbler. 1900, in K. Brandt's Nordische Plankton, heft 14, p. 27, figs. 27–30. Millett, 1903, Journ. R. Micr. Soc., p. 690.

This species has been already recorded from the "Challenger" station 169, off the east coast of New Zealand, 700 fathoms.

Our specimens are not numerous, and vary considerably in size.

Genus **Sphæroidina,** d'Orbigny.

Sphæroidina bulloides, d'Orbigny.

Sphæroidina bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 267, No. 1; modèle No. 65. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 325, pl. lxxi, fig. 1. Millett, 1903, Journ. R. Micr. Soc., p. 692.

This species is also one of the forms obtained from the east coast of New Zealand by the "Challenger." It is very rare in our series.

Genus **Pullenia,** Parker and Jones.

Pullenia sphæroides, d'Orbigny sp.

Nonionina sphæroides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 293, No. 1; modèle No. 43.

Pullenia sphæroides, d'Orb. sp., Egger, 1893, Abhandl. k. bayer. Akad. Wiss., cl. ii, vol. xviii., abth. ii, p. 372, pl. xix, figs. 30, 31. Chapman, 1900, Proc. Calif. Acad. Sci., ser. 3, Geol., vol. i, p. 252, pl. xxx, fig. 6. Millett, 1903, Journ. R. Micr. Soc., p. 691.

One typical specimen of this widely distributed form found in our series.

Pullenia quinqueloba, Reuss sp.

Nonionina quinqueloba, Reuss, 1851, Zeitschr. deutsch. geol. Gesellsch., vol. iii, p. 47, pl. v, figs. 31 *a, b*.

Pullenia quinqueloba, Reuss sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 324, pl. lxx, fig. 5.

This species is also very rare in the present series. It has been recorded from the east coast of New Zealand (sta. 169).

Family ROTALIIDÆ.

Subfamily ROTALIINÆ.

Genus **Truncatulina**, d'Orbigny.

Truncatulina tenuimargo, Brady.

Truncatulina tenuimargo, Brady, 1884, Rep. Chall., vol. ix, p. 662, pl. xciii, figs. 2, 3. Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 399, pl. xvi, figs. 7–9.

This elegant little species is apparently almost confined to the Southern Hemisphere. It has already been found off the shores of New Zealand, and is a well-known Australian species. Our specimens have the keel strongly accentuated, and the chambers showing a nodulous appearance on the inferior surface as in Brady's figure 2.

Not common in our sample.

Truncatulina reticulata, Czjzek sp.

Rotalina reticulata, Czjzek, 1848, Haidinger's Naturw. Abhandl., vol. ii. p. 145, pl. xiii, figs. 7–9.

Planorbulina reticulata. Cz. sp., Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix, No. 1, p. 72.

Truncatulina reticulata, Cz. sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 334, pl. lxxviii, fig. 3. Chapman, 1901, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 194. Millett, 1904, Journ. R. Micr. Soc., p. 491.

T. reticulata has been previously found in the South Pacific, but it does not seem to have been recorded from the neighbourhood of the present locality. It is very rare in our series.

Truncatulina wuellerstorfi, Schwager sp.

Anomalina wuellerstorfi. Schwager, 1866, "Novara" Exped., geol. Theil, vol. ii, p. 258, pl. vii, fig. 105.

Truncatulina wuellerstorfi, Schwager sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 333, pl. lxxvii, fig. 1. Millett, 1904, Journ. R. Micr. Soc., p. 492.

The above species is represented in the present series by a fair number of specimens. It does not appear to have been recorded from the vicinity of Great Barrier Island.

Brady regards this form as of essentially deep-water habit. In the South Pacific its range in depth is from 210 to 1940 fathoms, so that it is rather surprising to meet with so many typical specimens in our sounding at 110 fathoms.

Truncatulina lobatula, Walker and Jacob sp.

Nautilus lobatulus, Walker and Jacob, 1798, Adams's Essays, Kanmacher's ed., p. 642, pl. xiv, fig. 36.

Planorbulina lobatula, W. and J. sp., 1894, K. Svenska Vet.-Akad. Handl., vol. xxv, p. 88, pl. xv, fig. 774.

Truncatulina lobatula, W. and J. sp., Chapman, 1902, Proc. R. Soc. Edin., vol. xxiii, p. 392, pl. i, figs. 2, 3. Millett, 1904, Journ. R. Micr. Soc., p. 491.

Three typical specimens were found in the present sample. The species has been already recorded from the east coast of New Zealand (sta. 169).

Truncatulina variabilis, d'Orbigny.

Truncatulina variabilis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 279, No. 8. Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 404, pl. xvi, figs. 57–59, 63, 64. Chapman, 1901, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 193. Millett, 1904, Journ. R. Micr. Soc., p. 492.

This species is rare in the present series. The examples found are characteristic.

Truncatulina ungeriana, d'Orbigny sp.

Rotalina ungeriana, d'Orbigny, 1846, Foram. Foss. Vienne, p. 157, pl. viii, figs. 16–18.

Planorbulina ungeriana, d'Orb. sp., Goës, 1894, K. Svenska Vet.-Akad. Handl., vol. xxv, p. 90, pl. xv, fig. 780.

Truncatulina ungeriana, d'Orb. sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 333, pl. lxxvii, fig. 2. Chapman, 1901, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 194. Millett, 1904, Journ. R. Micr. Soc., p. 493.

The specimens met with are fairly numerous, and one example shows a tendency towards a redundant growth of the last chamber.

Truncatulina akneriana, d'Orbigny sp.

Rotalina akneriana, d'Orbigny, 1846, Foram. Foss. Vienne, p. 156, pl. viii, figs. 13–15.

Truncatulina akneriana, d'Orb. sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 333, pl. lxxvii, fig. 5. Millett, 1904, Journ. R. Micr. Soc., p. 494.

Three typical examples found.

Truncatulina pygmæa, Hantken.

Truncatulina pygmæa, Hantken, 1875, Mittheil. Jahrb. ung. geol. Anstalt, vol. iv, p. 78, pl. x, fig. 8. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 334, pl. lxxvii, fig. 6. Chapman, 1901, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 194.

This species is usually found in deep water; it has, however, occurred in the lagoon at Funafuti, Ellice Islands. Very rare in the present series.

Truncatulina haidingeri, d'Orbigny sp.

Rotalina haidingeri, d'Orbigny, 1846, Foram. Foss. Vienne, p. 154, pl. viii, figs. 7–9.

Truncatulina haidingeri, d'Orb. sp., Brady, 1884, Rep. Chall., vol. ix, p. 663, pl. xcv, figs. 7 *a–c.*

T. (Rotalina) haidingeri, d'Orb. sp., Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 401, pl. xvi, figs. 25–27.

T. haidingeri, d'Orb. sp., Millett, 1904, Journ. R. Micr. Soc., p. 493.

This species is very abundant in the present sounding, and it attains the unusually large size of 2·3 mm. in diameter. Besides the typical specimens there are some which seem to link, by their depressed superior face, the above species with a form like *T. præcincta,* Karrer, or *T. dutemplei,* d'Orb. sp. It is somewhat singular, considering its abundance, that this species has not hitherto been recorded from the locality.

Truncatulina (?) præcincta, Karrer sp.

Rotalina præcincta, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii, p. 189, pl. v, fig. 7.

Truncatulina præcincta, Karrer sp., Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 334, pl. lxxviii, fig. 1. Millett, 1904, Journ. R. Micr. Soc., p. 494.

A few specimens of a plano-convex form were met with. They are not quite typical, in having the limbate sutures only feebly developed.

Flint records *T. præcincta* from the Gulf of Mexico, at 169 and 196 fathoms, and Millett from the Malay Archipelago.

Genus **Anomalina,** Parker and Jones.

Anomalina polymorpha, Costa.

Anomalina polymorpha, Costa, 1856, Atti dell' Accad. Pontan., vol. vii, p. 52, pl. xxi, figs. 7–9. Brady, 1884, Rep. Chall., vol. ix, p. 676, pl. xcvii, figs. 3–7. Flint, 1899, Rep. U.S. Nat. Mus. (1897), p. 336, pl. lxxix, fig 3 Chapman, 1901, Proc. R. Soc. Edin., vol. xxiii, p. 392, pl. i, figs. 4–6.

One specimen having a more than usually truncatulinoid test occurred in our sample.

A. polymorpha has already been obtained by the "Challenger" west of New Zealand, at 275 fathoms.

Genus **Pulvinulina,** Parker and Jones.

Pulvinulina truncatulinoides, d'Orbigny sp.

Rotalina truncatulinoides, d'Orbigny, 1839, Foram. Canaries, p 132, pl. ii, figs. 25–27.
R. micheliniana, d'Orbigny, 1840, Mém. Soc. Géol. France, sér. 5, vol. iv, p. 31, pl. iii, figs. 1–3.
Pulvinulina truncatulinoides, d'Orb. sp., Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft. 14, p. 17, fig. 16.
P. micheliniana, d'Orb. sp., Millett, 1904, Journ. R. Micr. Soc., p. 500.

Although there seems to be reason for supposing that d'Orbigny's two works, to which reference is made above, were published almost simultaneously, yet the actual dates of publication differ, and therefore, according to the rule of priority, the better-known specific name, *P. micheliniana*, unfortunately must lapse.

This species has been already recorded for the South Pacific, and notably at sta. No. 169. It is not uncommon in our series.

Pulvinulina crassa, d'Orbigny sp.

Rotalina crassa, d'Orbigny, 1840, Mém. Soc. Géol. France, ser. 5, vol. iv., p. 32, pl. iii, figs. 7, 8.
Pulvinulina crassa, d'Orbigny sp., Flint, 1899, Rep. U.S. Nat. Mus. (897), p. 329, pl. lxxiv, fig. 1. Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft 14, p. 17, figs. 12, 14, 15. Millett, 1904, Journ. R. Micr. Soc., p. 500.

This species has been recorded from the east coast of New Zealand (sta. 169). It is rather rare in our series.

Pulvinulina canariensis, d'Orbigny sp.

Rotalina canariensis, d'Orbigny, 1839, Foram. Canaries, p. 130, pl. i, figs. 34–36.
Pulvinulina canariensis, d'Orb. sp., Rhumbler, 1900, in K. Brandt's Nordische Plankton, heft 14, p. 16, figs. 10 *a*, *b*, 11. Millett, 1904, Journ. R. Micr. Soc., p. 500.

Previously recorded from the South Pacific. It is rare in our sounding.

Pulvinulina auricula, Fitchel and Moll sp.

Nautilus auricula, var. *α*, Fichtel and Moll, 1878, Test. Micr., p. 108, pl. xx, figs. *a–c*.
Pulvinulina auricula, F. and M. sp., Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 415, pl. xvii, figs. 26–28.

This species is not uncommon in the present series.

It has occurred in the South Pacific at depths between 17 and 275 fathoms ("Challenger"). Egger also records it from Western Australia.

Pulvinulina schreibersii, d'Orbigny sp.

Rotalina schreibersii, d'Orbigny, 1846, Foram. Foss. Vienne, p. 154, pl. viii, figs. 4–6.

Pulvinulina schreibersii, d'Orb. sp., Egger, 1893, Abhandl. k. bayer. Ak. Wiss., cl. ii, vol. xviii, abth. ii, p. 409, pl. xviii, figs. 31–33, 67–69.

This handsome species is not uncommon in our series.

Brady notes this form as being almost peculiar to the South Pacific.

Genus **Rotalia,** Lamarck.

Rotalia soldanii, d'Orbigny.

Rotalia (Gyroidina) soldanii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 278, No. 5; modèle No. 36.

Rotalina soldanii, d'Orb. sp., Goës, 1894, K. Svenska Vet.-Akad. Handl, vol. xxv, p. 99, pl. xvi, fig. 812.

Rotalia soldanii, d'Orb. sp., Millett, 1904, Journ. R. Micr. Soc., p. 503.

Rare; somewhat diminutive specimens.

Rotalia papillosa, var. **compressiuscula,** Brady.

Rotalia papillosa var. *compressiuscula*, Brady, 1884, Rep. Chall., vol. ix, p. 708, pl. cvii, figs. 1 *a–c*; pl. cviii, figs. 1 *a–c*.

This is a Pacific species, with a rather wide distribution in that area. It does not appear to have been previously found in the neighbourhood of Great Barrier Island.

Rather common.

Rotalia clathrata, Brady.

Rotalia clathrata, Brady, 1884, Rep. Chall., vol. ix, p. 709, pl. cvii, figs. 8, 9.

The localities whence this species has been obtained are all in the South Pacific, and lie between Australia and New Zealand. The nearest position to Great Barrier Island was the "Challenger" station 169.

Rare in our series.

Subfamily POLYSTOMELLINÆ.

Genus **Nonionina,** d'Orbigny.

Nonionina umbilicatula, Montagu sp.

Nautilus umbilicatulus, Montagu, 1803, Test. Brit., p. 191 Suppl., p. 78, pl. xviii, fig. 1.

Nonionina umbilicatula, Mont. sp., Egger, 1893, Abhand. k. bayer. Ak. Wiss, cl. ii, vol. xviii, abth. ii, p. 426, pl. xix, figs. 36, 37. Millett, 1904, Journ. R. Micr. Soc., p. 600.

Brady records this species as abundant in the South Pacific. It was also found by Millett in the Malay Archipelago. Egger obtained it from soundings taken by the "Gazelle" off Mauritius and New Guinea.

Rare in our series.

REPORT ON THE OSTRACODA.

All the species of *Ostracoda* here recorded, with the exceptions of *Asterone australis*, Brady, and *Cytherideis hedleyi*, sp. nov., have been previously described in the report on the dredgings made by the "Challenger,"* and the former species in a later publication by the same author.† The "Challenger" station nearest ours which yielded *Ostracoda* is No. 167, west of New Zealand, and from this three species only in common with our series are recorded. Among other localities which afford species in common with those of our list are: Off Booby Island, near Cape York, north-east Australia ("Challenger" sta. 187), and Cocos Island, Indian Ocean (coll., C. W. Andrews). Twelve species of *Ostracoda* of known forms occur in our dredging, but only four of these occur in each of the localities above mentioned; and, curiously, both of these dredgings were taken in quite shallow water. The species which occur both in our list and that from Booby Island are *Cythere tetrica*, *C. crispata*, *C. cancellata*, and *Xestoleberis margaritea*. Those from Cocos Island common to our list are *C. cancellata*, *C. prava*, *C. dictyon*, and *Xestoleberis margaritea*.

The following is a list of the *Ostracoda* found in the present material, and the species new to the list given in the "Index Faunæ Novæ-Zealandiæ" are marked with an asterisk. Of the fourteen species of *Ostracoda* given below, nine are new to the New Zealand area.

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* Reports "Challenger" Expedition, Zoology, pt. iii, 1880: *Ostracoda*, G. S. Brady.

† Trans. R. Soc. Edin., 1890, vol. xxxv, pt. ii (No. 14).

Cythere cancellata, G. S. Brady.
C. crispata, G. S. B.
C. tetrica, G. S. B.
C. dictyon, G. S. B.
C. prava, Baird sp.
C. dasyderma, G. S. B.
Krithe producta, G. S. B.
Xestoleberis margaritea, G. S. B. sp.
X. africana, G. S. B.
Cytherideis hedleyi, sp. nov.
Cypridina danæ, G. S. B.
Asterope australis, G. S. B.
Cytherella polita, G. S. B.
C. pulchra, G. S. B.

OSTRACODA.

Section PODOCOPA.

Family Cytheridæ.

Genus **Cythere**, Müller.

Cythere cancellata, G. S. Brady.

Cythere cancellata, G. S. Brady, 1868, Le Fonds de la Mer, vol. i, p. 62, pl. vii, figs. 8–9. *Idem*, 1880, Rep. Chall., Zoology, p. 73, pl. xiv, figs. 9 *a–e*. Chapman, 1902, Proc. Zool. Soc. Lond., p. 230.

Previously recorded from Tongatabu, 18 fathoms, and off Booby Island, Torres Strait, 6 to 8 fathoms. Also from Java (G. S. Brady).

The writer has recorded it from the littoral sands of the seaward face of Cocos Island (coll. by Dr. C. W. Andrews).

Cythere crispata, G. S. Brady.

Cythere crispata, G. S. Brady, 1868, Ann. and Mag. Nat. Hist., ser. 4. vol. ii, p. 221, pl. xiv. figs. 14, 15. *Idem*, 1880, Rep. Chall., Zool., pt. iii, p. 72, pl. xiv, figs. 8 *a–d*.

This species has a wide distribution. The "Challenger" dredgings yielding this species were from Port Jackson, 2 to 10 fathoms; Booby Island, 6 to 8 fathoms; and from anchor-mud at 7 fathoms in Hong Kong Harbour.

A right valve of this species was found in our dredging; it is not so sharply sculptured as in typical specimens, and at first sight would suggest affinity with *C. canaliculata*, Reuss. Our specimen differs from the last-named, however, in having the anterior extremity of the carapace, in edge view, decidedly wedge-shaped.

Cythere tetrica, G. S. Brady.

Cythere tetrica, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 104, pl. xxiii, figs. 5 *a–d*.

This somewhat striking form has been previously recorded only from Booby Island, Torres Strait, 6 to 8 fathoms.

One right valve found in our series.

Cythere dictyon, G. S. Brady.

Cythere dictyon, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 99, pl. xxiv, figs. 1 *a–y*.

Five separate valves of this widely distributed species were found, one of which appears to belong to a full-grown female, and shows the posterior spines arranged along the border of the shell. Another example is a small valve of the same sex, whilst the remainder are valves of male specimens.

Cythere prava, Baird sp.

Cythereis prava, Baird, 1850, Proc. Zool. Soc., pt. xviii, p. 254 (*Annulosa*), pl. xviii, figs. 13–15.

Cythere prava, Baird sp., G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 92, pl. xxii, figs. 4 *a–f*. G. S. Brady, 1890, Trans. R. Soc. Edin., vol. xxxv, p. 502. Chapman, 1902, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 426. *Idem*, 1902, Proc. Zool. Soc. Lond., p. 231.

C. prava is a South Pacific form, but not exclusively so. It appears to be more at home in shallow water. Our specimen is a right valve, the surface of which is more than usually coarsely sculptured.

Cythere dasyderma, G. S. Brady.

Cythere dasyderma, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 105, pl. xvii, figs. 4 *a–f*; pl. xviii, figs. 4 *a–f*.

In the "Challenger" dredgings this species was characterized as a deep-water form, so that its occurrence in the present sounding is somewhat exceptional. It is also widely distributed.

One right valve.

Genus **Krithe**, Brady, Crosskey and Robertson.

Krithe producta, G. S. Brady.

Krithe producta, G. S. Brady 1880, Rep. Chall., Zool., pt. iii, p. 114, pl. xxvii, figs. *a–j*. Chapman, 1902, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 427.

This very variable form occurs oftenest in deep water. The deepest sounding from which Dr. Brady obtained his specimens was taken at 1,675 fathoms. The writer records this species from the "Penguin" soundings round Funafuti at 1,489, 1,995, and 2,715 fathoms. He also obtained this species from soundings in the Arabian Sea, near the Laccadive Islands (s.s. "Investigator").

Not uncommon, but rather small, in the dredging off Great Barrier Island.

Genus **Xestoleberis**, G. O. Sars.

Xestoleberis margaritea, G. S. Brady sp.

Cytheridea margaritea, G. S. Brady, Trans. Zool. Soc., 1865, vol. v, p. 370, pl. lviii, figs. 6 *a–d*.

Xestoleberis margaritea, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 127, pl. xxx, figs. 2 *a–g*. Chapman, 1902, Journ. Linn. Soc. Lond. (Zool.), vol. xxviii, p. 429. *Idem*, 1902, Proc. Zool. Soc. Lond., p. 231.

Dr. Brady found this species in the "Challenger" dredgings at one locality only—namely, off Booby Island, Torres Strait, 6–8 fathoms. The same author also records it from the Mediterranean and the Mauritius. The writer found it in the shallow-water sands of the outer beach and lagoon of Funafuti, where it was fairly common, and in the lagoon sands of Cocos Island.

One perfect carapace found off Great Barrier Island.

Xestoleberis africana, G. S. Brady.

Xestoleberis africana, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 126, pl. xxx, figs. 4 *a–c*.

This is a very rare and restricted form. It was originally recorded from Simon's Bay, South Africa, 15 to 20 fathoms.

One left valve found in our dredging from Great Barrier Island.

Genus **Cytherideis**, Jones.

Cytherideis hedleyi, sp. nov.

Plate III, figs. 8 *a–c*.

Description.—Carapace elongated, compressed. Seen from the side, arcuate and siliquose; depressed in front; greatest height about the middle; posterior extremity slightly produced at the ventral angle; back evenly arched, ventral edge sinuous. Edge view elongate-ovate, rounded at the back, compressed in front; greatest thickness about the middle of the lower third. Surface of carapace ornamented with closely set polygonal areolæ or pittings, arranged in more or less regular concentric lines. A linear series of muscle-spots situated in a lateral depression of the carapace just below the median area. Length, 0·6 mm.; height, 0·225 mm.; greatest thickness of carapace, about 0·66 mm.

Affinities.—In outline our species is somewhat comparable with *C. foveolata*, G. S. Brady,* with the exception that the valves of that species are not produced in the postero-ventral region; it further essentially differs from ours in the surface-markings of the carapace, which in *C. foveolata* consist of a minute and dense punctation.

Another form of the same genus which we may compare with the present species is *C. andrewsi*, Chapman,† which, however, shows the following differences: Test less depressed at the anterior end; ornament not so distinctly polygonally areolate; and muscle-spots arranged in rosette form.

Very rare in our sounding.

Section MYODOCOPA.

Family CYPRIDINIDÆ.

Genus **Cypridina,** Milne-Edwards.

Cypridina (?) danæ, G. S. Brady.

Cypridina danæ, G. S. Brady, 1880, Rep. Chall., Zool., pt. iii, p. 156, pl. xxxvi, figs. 2 *a–d*.

The specimen before us is somewhat crushed, making an exact comparison difficult. It resembles the above species fairly closely in side view, but the relative proportions of the carapace in edge view are not clearly seen. Our specimen, like that of Brady's, is partially chitinous in places, and the anterior notch and posterior truncated beak are similarly shaped as in *C. danæ*. Brady's species is based on a single specimen obtained from Kerguelen Island at a depth of 120 fathoms.

Genus **Asterope,** Philippi.

Asterope australis, G. S. Brady.

Asterope australis, G. S. Brady, 1890, Trans. R. Soc. Edin., vol. xxxv, pt. ii, p. 515, pl. iv, figs. 1, 2. *Idem*, 1898, Trans. Zool. Soc., vol. xiv, p. 431, pl. xliii, figs. 1–8.

It is of great interest to meet with this genus in the present collection, since the cypridinads are comparatively rare in the Southern Hemisphere, so far as they are at present known. Brady's original specimens of *A. australis* came from the coral islands of the Pacific—Nouméa, 2–4 fathoms; Suva, inside reef; Mango Island, fringing-reef; Apia, Upolu, reef and shore pools.

One typical carapace was found in the present sounding off Great Barrier Island.

* Ann. Mag. Nat. Hist., ser. 4, vol. vi, 1870, p. 454, pl. xix, figs. 1–3.
† Proc. Zool. Soc. Lond., 1902, p. 229, text figure 27.

Section PLATYCOPA.

Family Cytherellidæ.

Genus **Cytherella**, Jones.

Cytherella polita, G. S. Brady.

Cytherella polita, Brady, 1868, Les Fonds de la Mer, p. 161, pl. xix, figs. 5–7. *Idem*, 1880, Rep. Chall., Zool., pt. iii, p. 172, pl. xliii, figs. 5 *a–c* ; pl. xliv, figs. 1 *a–g*.

This species has been recorded by Brady from Port-au-Prince, West Indies ; Wellington Harbour, New Zealand ; and from the mouth of the Rio de la Plata.

Two separate valves of a small and large individual respectively are now recorded from Great Barrier Island, 110 fathoms.

Cytherella pulchra, G. S. Brady.

Cytherella pulchra, G. S. Brady, 1865, Trans. Zool. Soc., vol. v, p. 361, pl. lvii, figs. 1 *a–d*. *Idem*, 1880, Rep. Chall., Zool., pt. iii, p. 174, pl. xliv, figs. 3 *a*, *b*.

This species has previously occurred at Bermudas, 435 fathoms ; Port Jackson, Australia, 2–10 fathoms ; west coast of New Zealand, 150 fathoms ; and off Ascension Island, 420 fathoms.

A typical example of this species was found in our sample off Great Barrier Island.

[Note.—Examples of all the species of *Foraminifera* and *Ostracoda* referred to in this paper, as well as the types, are deposited in the Colonial Museum, Wellington.]

EXPLANATION OF PLATE III.

Fig. 1. *Planispirina sphæra*, d'Orbigny sp. : *a*, lateral aspect of a specimen with labyrinthic aperture ; *b*, ditto, oral aspect. × 20.

Fig. 2. *Brachysiphon corbuliformis*, gen. et sp. nov. : *a*, oral aspect ; *b*, lateral aspect. × 30.

Fig. 3. *B. corbuliformis*, gen. et sp. nov. Another specimen, aboral view. × 30.

Fig. 4. *Spiroplecta sagittula*, Defr. sp., var. *fistulosa*, Brady. Lateral aspect ; to show senile character of later chambers, like that of *Textularia agglutinans*, var. *porrecta*, Brady. × 20.

Fig. 5. *Nodosaria (Dentalina) obliqua*, Linn. sp., var. *vertebralis*, Batsch var. × 10.

Fig. 6. *N. (D.) filiformis*, d'Orbigny. Specimen having pointed aboral end like *N. (D.) elegans*, d'Orbigny sp. × 20.

Fig. 7. *Frondicularia reussi*, Karrer. Lateral aspect. × 20.

Fig. 8. *Cytherideis hedleyi*, sp. nov. : *a*, left valve ; *b*, edge view of valve ; *c*, end view. × 60.

Art. XVIII.—*Maori Place-names: with Special Reference to the Great Lakes and Mountains of the South Island.*

By J. Cowan.

[*Read before the Wellington Philosophical Society, 4th October,* 1905.]

In this paper I do not propose to enter at length upon the large question of Maori nomenclature, about which so much has been written, but simply to note some hitherto unrecorded names of interest in the South Island, more particularly those of the lakes and mountains, which I have from Maori sources. During the last few years attention has been many times directed to the desirability of preserving Maori place-names wherever possible, and to the necessity for fixing the correct orthography of many of the Native names at present spelled in a more or less inaccurate fashion. We have a good many cases of carelessly spelled names in and around Wellington—even the Native names of some of the streets are incorrect—but there is no reason why this sort of thing should be perpetuated. In the South Island, however, matters are much worse. I could give a list of many scores of names of localities in the Island—towns, villages, railway-stations, rivers, lakes, and mountains—all erroneously spelt, many of them atrociously mangled by the *pakeha.* Those present who are acquainted with Maori will no doubt be able to recall many mistakes of this sort. One glaring instance is typical of the careless method of orthography common throughout the South Island. "Kurow" (locally pronounced as "Kew-ro") is the official name of a township and railway-station in north Otago. This, as it stands, is neither Maori, English, nor Japanese. As a matter of fact it should be "Kohu-rau," which means "many mists," or "roofed with mists"—the name of a mountain near the township. There is something appropriate and poetic in the name "Kohu-rau"; but I suppose "Kurow" it will be henceforth and always.

A great many of the names given to mountains and lakes in the South Island are personal names. The Maoris bestowed the names of their chiefs upon prominent features of the landscape, just as we *pakehas* name them after our early explorers, and our statesmen, and other men of note. The attempts made to interpret these names under the mistaken idea that they are locally descriptive titles have led to some curious and amusing blunders. Other names, again, are tritely appropriate to the locality. Many others are exceedingly interesting because they memorise the ancient homes of the Maori in the South Sea

Islands—they are importations from Hawaiiki, and are of great assistance to Polynesian scholars in tracing with exactness the olden homes of our Native race in the Society Islands and the Cook Group. The Maori is as fond as the Anglo-Saxon and the Celt of taking his home-names with him across the sea. Names of this class are: "Rarotonga" (Centre Island, in Foveaux Strait); "Arowhenua" or "Arowhena," near Temuka; "Motutapu," "Aorangi," "Arahura," "Takitimu," "Hikuraki," &c. The name "Arahura" (the greenstone-bearing river near Hokitika, on the West Coast) is in itself a most interesting reminiscence of Hawaiiki—a story in a word. It is identical with "Ara'ura," the former and classic name of Aitutaki, in the Cook Islands—the group to which Rarotonga also belongs. Many years ago I had occasion, in the course of newspaper work, to board a small Native-owned schooner while she was beating up into Auckland Harbour with a cargo of oranges from Aitutaki. She had been wrecked at that island, refloated by the Natives, and renamed by them the "Ara'ura," which I learned from the Maori crew was the original and very ancient name of their island. It was given to the river on the west coast of New Zealand by the early navigator Ngahue. "Takitimu" is another instance of this sort. It is the name of a high range in the south, near Lakes Manapouri and Te Anau, and is also the name of a locality on the tropic Island of Rarotonga. The name, say the Southland Maoris, was given to the mountain by Tamatea, the chief who commanded the "Takitimu" (or "Takitumu") canoe, one of the historic fleet which arrived on these shores from Hawaiiki about six centuries ago, some time after Ngahue's exploring voyage to New Zealand. The mountain is in a sense the Maori Ararat, for it was here that the "Takitimu" canoe is fabled to have found its final resting-place in the days when the ocean flowed over the plains of Southland and washed the feet of the Takitimus. From some of the Maoris, too, one hears the fanciful legend that the range is the "Takitimu" canoe capsized, metamorphosed into a gigantic mountain; in proof of which they point to the abruptly sloping terminals of the range, not unlike the shape of the bow and stern of an up-ended canoe. "Takitimu" is still an honoured name in the olden home of the Maori. A Native-built schooner of the rough-and-ready home-made type which visited Auckland some years ago from Rarotonga, manned by a white captain and a Maori crew, bore the historic name "Takitumu," and voyaged over the self-same ocean route that Tamatea's Polynesian adventurers took in their much frailer craft six hundred years before.

A beautiful and very appropriate name is "Motu-rau," the ancient name of Lake Manapouri. It means "hundred islands" or "multitude of islands." If you visit Manapouri you will readily understand why this name (which I do not think has ever previously been recorded) came to be given to the lake, the most beautiful water-sheet in New Zealand. It is crowded with islands of all shapes and sizes. All around you they lie as you sail up the lake, some high and rocky, some tiny dots of granite or sandstone, but all wooded so luxuriantly that they seem like tree-groves floating on the surface of the water. No matter how small the islet, if only the size of a table, it supports as many trees and shrubs as it can well hold. The "Lake of a Hundred Islands" must have been an ideal cruising-ground for the neolithic Maori. The ancient Ngatimamoe gave the lake this name "Motu-rau," according to the Murihiku Maoris, who are in part descended from the Ngatimamoe; but probably the name is of even greater antiquity, and dates back to the era of the Waitaha.

"Manapouri" (a combination of two words meaning "authority" or "prestige," and "sorrowful") is simply a modernised rendering of the name "Manawa-pore" (or "Manawa-popore"), signifying the violent throbbing of the heart, as after great exertion or under intense emotion. "Manawa-pore" is stated by the Southland Maoris to be really the name of the North Mavora Lake, lying between Wakatipu and Te Anau. The name is said to have been transferred in error to the larger lake by the early surveyors and map-makers. Various more or less fanciful interpretations of the corrupted name "Manapouri" or "Manawa-pouri" have appeared in print, and imaginative writers have connected it with the story of the fugitive tribe Ngatimamoe. "Manawa-pore" was, however, originally the name of a person, a tribal ancestor of chiefly rank, as was also the name "Te Anau."

Lake Te Anau, I am informed by the old Natives of Murihiku, was named after a woman, the daughter of the chief Hekeia, one of the early immigrants from Hawaiiki, after whom a Southland mountain has been named. As in the case of "Manapouri," many imaginary interpretations of "Te Anau" have appeared in print. The latest invention in this direction appeared in a Dunedin paper recently, when a long poem on Te Anau was published, in which it was explained that "Te Anau" meant "wandering lake." How, or why, or where the lake "wandered" was left to the reader's imagination. The South Mavora Lake is known to the old Maoris as "Hikuraki" (a dialectical variant of the North Island "Hiku-rangi"), a common Maori place-name, meaning "the tail of the sky"—the horizon. It is interesting to note that this is also the name of a mountain in Rarotonga Island. It was no doubt given to this mountain-lake by the "Takitimu" immigrants.

Of the great southern lakes, Wakatipu's name is the most difficult of explanation. The Maoris inform me that "Whakatipu" (with an "h") is the correct name, but the incident which led to this being given to the lake has passed out of the recollection of the Maoris whom I have consulted. "Whakatipu" means "to nourish, to rear," from the root word *tipu* or *tupu* ("to grow, to spring up as a tree"). The actual origin of the great lake is, however, accounted for in Native legend in a fashion thoroughly Maori. When the chief Rakaihaitu, one of the very first of the Polynesian sea-rovers to explore this country (long before the sailing of the "Takitimu" and other historic canoes—probably about a thousand years ago), arrived in the South Island he took possession of the eastern seaboard and the land sloping up therefrom to the great snowy mountains. As was customary, the pioneers named many prominent features of the landscape after themselves, and so *tapa'd* the country for their families and descendants; and Rakaihaitu, in common with many other Polynesian explorers, was in time credited with the deeds of a demi-god. The classical name for the South Island lakes is "Nga-puna-wai-karikari-a-Rakaihaitu" ("The water-pools dug by Rakaihaitu"). The energetic chief is said to have begun his labours by scooping out with his great *ko* (the wooden spade used in the *kumara* plantations) the bed of the lake known as Rotoiti, south of Nelson. Then he strode southwards, halting frequently to form a lake where he thought it was needed. His crowning triumph was Whakatipu, whose crooked channel he hollowed out between the mountains with infinite toil and many incantations. Travelling north again, he completed his herculean pilgrimage by digging out Lakes Waihora (Ellesmere) and Wairewa (Lake Forsyth), near Banks Peninsula—and rested from his labours. "Nga-wai-karikari-a-Rakaihaitu" is a proverbial expression still used by the Maoris in allusion to the lakes, as the figurative phrase "Nga-whata-tu-a-Rakaihaitu" ("Rakaihaitu's lofty food-stores") is used to describe the high cliffs of the South Island coast.

At the lower end of Lake Wakatipu, not far from the Kingston Railway-station, there is a group of craggy peaks called by the Maoris "the Fairy Mountains." These heights tower 5,000 ft. immediately above the steamer on the left as you start up the lake. They were regarded with some dread by the old Maoris, who peopled them with giants and fairies (*maeroero*). The superstitious Native of olden days, for ever hearing uncanny sounds and reading strange omens in earth and sky, was careful not to venture too close to the haunts of the *maeroero.* On gloomy and misty days, when the fog descended and enveloped the heights, the fairy people could be heard singing songs in a ghostly cadence and calling to each other; and then, too, resounded the faint and plaintive music of the *koauau,* or nose-flute, and the doleful note of the *putorino* horn, and the voices of the fairy children laughing and singing above the clouds. A quaint story of these *maero* mountains used to be told by the late chief Paitu, who lived at Riverton. When he was a youth, he said, he lived at the *kaika* of Takerehaka (where Kingston now stands). The shores of Whakatipu abounded in fat woodhens (*weka*), and Paitu and his companions spent much of their time in hunting them for food. The elder people warned him not to cross a certain little stream at the base of the mountains, for beyond it, they said, was the home of the *maeroero,* amidst dark overhanging cliffs. "You may hear the cry of the *weka* beyond the creek," Paitu was told, "but beware—the *maero* will have you if you cross." One night Paitu, hunting *wekas* as usual with his dog, found himself close to the forbidden stream, and, hearing the cry of a *weka* on the other side, waded through, unmindful of the warning. He crept along through the shrubbery to a clump of *mikimiki* bushes, where the bird was feeding on the berries. Holding his dog in leash, he began to *turutu*—that is, to imitate the cry of the *weka,* so as to lure it within catching-distance. Enticing the woodhen closer and closer, he quietly sent his dog at it. The dog seized the bird, but next moment there was a terrific yelp, and the animal flew back trembling and whining; and through the darkness Paitu heard a gruff voice exclaim "*E-e! Taku weka momona*" ("Ha! my fat woodhen"). It was the *maero!* With hair on end Paitu left his *weka* to the *maero* and splashed homeward through the creek, fearing every moment to feel the grip of the mountain-ogre on his shoulder; and he and his dog ventured no more into the haunted spot. The old Maoris on the coast to this day speak of these dark and lowering heights as "*nga puke maeroero*" ("the hills of the fairies").

A familiar name to New-Zealanders is "Monowai," the modern name of a lake in the extreme south-west of the South Island, after which one of the Union Company's steamers is named. This name is generally pointed to as a curious combination of the Greek word *monos* ("one") and Maori *wai* ("water"). It was given by Mr. McKerrow, late Surveyor-General, who first surveyed the lake. It is not so generally known, however, that the correct Maori name of the lake is "Manokiwai," originally a personal name: this is the name by which it is known to the

Southland Maoris to-day. "Monowai" is really a corruption of "Manokiwai." (See Mr. McKerrow's note.*)

A memory of the vanished tribe Ngatimamoe is contained in the name "Wawahi-waka," which is that of an island in the upper part of Lake Wakatipu, called by the Europeans "Pigeon Island." "Wawahi-waka" means "splitting canoes"; it owes its origin to the ancient Ngatimamoe, and other people of the Stone age, who resorted here to fell and split up trees for the purpose of canoe-making. Totara pines of large size formerly grew on this island, now almost treeless.

Lakes Wanaka, Hawea, Pukaki, and numerous other southern lakes were named after persons of olden days. In Lake Wanaka there is a very remarkable little island containing a pretty lakelet, 500 ft. above the level of Wanaka—a lake within a lake. This island ("Manuka" or "Pigeon Island," the *pakeha* calls it) is "Te Mou-a-hou," meaning "Hou's islet." Another island in Lake Wanaka is "Motu-tapu," or "holy isle"—a very ancient and classic South-Sea-Island name. "Te Motu-tapu-a-Tinirau" will be familiar to students of Polynesian mythology. This was the original name of Mokoia Island in Lake Rotorua—the Olympus of the Arawa Tribe.

Turning to the mountains of the Southern Alps we find comparatively few of these great snowy peaks named by the Maoris, who did not care to venture far into the wastes of rock and ice. The beautiful Maori name "Ao-rangi" ("Ao-raki" in the South Island dialect) has been frequently but erroneously translated as "cloud-piercer," a purely fanciful interpretation. The "cloud of heaven" may be accepted as the literal meaning of "Ao-rangi." This place-name embodies a reminiscence of the fatherland of the Maori, for there is a high mountain named "Aora'i" (or "Ao-rangi") on the Island of Tahiti, in the Society Islands. Tradition also asserts that "Aorangi" was the name of one of the chiefs who arrived in the South Island from Hawaiiki in the canoe "Ara-i-te-uru,"

* Mr. McKerrow has kindly furnished the following note on the subject: "In September, 1862, when on my way through Riverton to engage in the reconnaissance survey of the country drained by the Waiau River, I met the well-known Maori, Solomon (since deceased), and learned from him that there were two lakes in the bush west of the river. He said that he had never seen them, but an old woman in his *kaika* had seen them when a girl, and that their names were—as I made out from his pronunciation—'Howloko' and 'Monowai.' 'Howloko' has since been corrected to 'Hauroto.' And 'Manokiwai,' which you state is the name by which the lake is known to the Middle Island Natives to-day, may probably be the name that Solomon gave me, although I was unable at the time to come nearer to it than the hybrid 'Monowai,' meaning 'one water.' That designation, as it happens, is not inapt, as the lake is mainly fed by one river."

circa 1350. Two other immigrants by this Polynesian viking-ship were Kirikiri-katata and Aroaro-kaihe. The former name was given by the Maori explorers to the Mount Cook Range, while that of Aroaro-kaihe was bestowed upon one of the icy peaks of Aorangi. The peak now known as Mount Tasman was at the same time named "Horo-koau." "Aorangi" was the term usually applied to Mount Cook by the Maoris on the west coast; those on the eastern plains generally called it "Kirikiri-katata." Although said to be originally a personal name, it is significant that these words may be used to denote a fissured or cracked mountain-side of gravel, which would exactly describe the deeply eroded couloir-riven end of the Mount Cook Range as seen from the Tasman Valley.

Mount Sefton's Native name is said by old Canterbury Maoris to be "Maunga-atua," meaning "the mountain of the god" (or holy mount). As in the case of Aorangi, this name is stated to have been conferred in honour of an ancestral chief who arrived on these shores in the "Ara-i-te-uru" canoe from the South Sea Islands. There is, however, a Native legend (probably a comparatively modern invention) supporting the title of "Maunga-atua" with the assertion that a spirit (*atua*) dwells in these tremendous solitudes, and that its thundering voice is heard in the crashing of the avalanches that continually fall from Sefton's ice-hung cliffs.

Perhaps the most descriptive of the South Island mountain names is that of Mount Aspiring, a very grand ice-clad peak little short of 10,000 ft. in height—the highest mountain south of the Aorangi alpine group. Its beautiful Maori name, never before recorded, is well worth preserving—"Titi-tea"—which may be interpreted as "steep peak of glistening white."

Very few of the names of the high mountain-peaks in the South Island map are Maori. "Tapuae-nuku," the highest point of the Kaikoura Ranges, is one of the exceptions. It may be interpreted either as "the footsteps of Uenuku" (full name "Tapuae-uenuku")—that is, the rainbow, which is the visible sign or *aria* of the god Uenuku—or as "moving or sliding footsteps." The Maori name of the Blue Mountains in Otago is also "Tapuae-nuku," which has been corrupted into "Tapanui," the present name of the town near the foot of these mountains. Mention of Kaikoura reminds me that old Ira Herewini, of Moeraki, tells me the full name of the locality is "Te Ahi-Kaikoura-a-Tama-ki-te-Rangi"—*i.e.*, the place where the early navigator Tama, the commander of the "Tairea" canoe, landed and kindled a fire to cook a meal of *koura*, or crayfish.

The expression "Te-Waka-a-Maui" ("the canoe of Maui"), as an ancient name for the South Island of New Zealand, is still occasionally heard from the lips of the old people of the Ngaitahu Tribe. The notion that it was from the South Island that Maui fished up the North ("Te Ika-a-Maui," "the fish of Maui") is, however, a purely southern concept. It would be hard to convince a northern Maori of the superior antiquity of the greenstone land. "Te Taumanu-o-te-Waka-a-Maui" ("the thwart of the canoe of Maui")—on which Maui stood when hauling up his land-fish—is said by the Ngaitahu to be the name of a place in the neighbourhood of Kaikoura.

An ancient mythological honorific title of Stewart Island (or Rakiura) is "Te Puka-o-te-waka-a-Maui," which means "the anchor of Maui's canoe."

But the subject of these place-names is one that cannot be dealt with in one paper. I have a very long list of South Island names not yet recorded in print, or, if recorded, only inaccurately. I believe that Mr. Justice Chapman has during the course of many years acquired a very considerable list of South Island place-names from the old Maoris, particularly from the late chief Rawiri te Maire, of South Canterbury. I hope that he will some day publish them. Another matter in connection with Maori place-names that should have attention is the pronunciation. New-Zealanders at any rate should have no excuse for mispronunciation of the names of their own homes, for the language is phonetic, and simple in the extreme; yet how often one hears such mispronunciation as "Tarangger" for "Tauranga," "Narranger" for "Ngauranga," "Mew-reety" for the beautiful name "Muritai" ("the sea-breeze"). The only remedy, I suppose, is to teach our school-teachers at least the Maori alphabet and some of the rudiments of the language, for it is no doubt in the schools that colonial children first hear many of these names so mispronounced.

Art. XIX.—*Some Historic Maori Personages.*

By Thomas W. Downes.

[*Read before the Wellington Philosophical Society, 1st November,* 1905.]

Plates XIV–XVII.

Students will agree that all facts that can possibly be obtained regarding the Maoris should be placed on record, for it seems only too true that the day is quickly coming when this interesting race will be but a memory. Their history has been largely supplied by the late Mr. John White. Messrs. Taylor, Best, Colenso, Smith, and Tregear deal largely with their manner of life; Archdeacon Williams has rendered great benefit to all students by his dictionaries; but, until lately, in point of art the Maori has been left severely alone. Mr. Hamilton's beautiful work, and Robley's "Moko," are almost the only works we have in this respect; and Angas alone has attempted to give us pictorial representations of the old-time warriors. I consider that I have therefore been singularly fortunate in coming across some very old unpublished sketches made about the year 1843 by the late J. A. Gilfillan, photographs of some of which I have much pleasure in submitting to this Society. For the privilege of examining the Gilfillan sketches and copying some of the most interesting I am indebted to the kindness and courtesy of T. Allison, Esq., of Wanganui, a grandson of the late Mr. Gilfillan, who, I might here say, was a middle-nineteenth-century artist of a high order. The sketches display careful and beautiful work, and there is abundant evidence that great pains have been bestowed on many of the representations in order to secure accuracy. I may mention that several pictures from this artist's brush are in collections in England and Australia (one in the Melbourne Art Gallery —"Captain Cook proclaiming New South Wales a British Possession, Botany Bay, 1770," which is reproduced in the "Picturesque Atlas of Australasia," page 8, Part i), and others are occasionally met with in New Zealand, whilst he has also illustrated a few literary publications. I am persuaded, therefore, that the portraits I am reproducing from the sketch-books are to be relied upon for accuracy, and should supersede those of the same personages already in existence.

Gilfillan's name is not unknown in New Zealand history, owing to the unfortunate and terrible massacre which took place at his farm at Matarawa, near Wanganui, on the 18th April, 1847. Several accounts of this sad event have been written, but I consider that one of the best is given in Power's "Sketches in New Zealand." Power was one of the rescue party which went out to Matarawa the morning after the massacre, and therefore, being almost an eye-witness, his account should be fairly correct.

There are in the original sketch-book already mentioned several names of great interest to all who study the history of New Zealand from the time of the incoming of the Britisher, and of these I am selecting the most prominent—namely, Te Rauparaha, Heke and his wife, and Maketu. Rauparaha and Heke are the two most illustrious of the Maori chiefs, or *rangatiras*, of the early days of New Zealand colonisation, and were perhaps the greatest warriors of their race. Heke, by reason of his determined opposition to British rule on any and every occasion, and Rauparaha, by his bloody ravages on other Maori tribes, and particularly the Ngaitahu of Wai Pounamu (the South Island) and the Muaupoko in the North, to say nothing of the part he played in the Wairau massacre, will ever be prominently placed in New Zealand history; whilst Maketu is best known as the chief who stood out most resolutely against the sale of the Wanganui lands to the New Zealand Company in 1840.

I am sorry that much of the beauty and delicacy of line that characterize the original drawings are altogether lost in my photographs, owing to the work being done with lead-pencil, and the paper having become stained and faded through age. I have been forced, therefore, to take a series of positives and negatives and so build up contrasts, which process has, however, given me some trouble, owing to the grain of the paper becoming intensified as well as the lines required. All the beautiful half-tones have been lost by this process, which was necessary in order to get the lines black enough for reproduction; but the outline and general drawing have not been interfered with.

Two pictures of Te Rauparaha have, so far as I am aware, already been published, but neither, in my opinion, is as fine as the one under notice.

It may not be out of place here to give a description of Rauparaha's general appearance, culled from various contemporary authorities. The Rev. Richard Taylor, who saw him a prisoner on board the "Calliope," says, in "Te Ika a Maui" (p. 54), "In stature he (Rauparaha) was not above 5 ft. 6 in., but his countenance was striking. He had a Roman or hooked nose, an eagle glance which read the thoughts of others without revealing his own, and a look which clearly marked his dauntless bearing." He had apparently a very slight deformity, for in "Savage Scenes" (vol. i, p. 35) Angas mentions that he had six toes on his left foot. This, however, is apart from present interest. E. J. Wakefield, in his "Adventures in New Zealand" (vol. i, p. 113), about 1840, says Rauparaha "was at least sixty years old, hale and stout, hair but slightly grizzled, features aquiline and striking, overhanging lips and retreating forehead, eyebrows wrinkled back when he lifted his deep sunken eyelids, and penetrating eyes." Thomson, in "Story of New Zealand" (vol. ii, p. 181), says, "In stature he was small and wiry, forehead broad and receding." Power, at page 51 of "Sketches in New Zealand," thus describes Rauparaha's general expression of features: "Placid and thoughtful, but with the least excitement they assume a malignant and wolfish expression; his small snaky eyes gleam, and his thin lips curl down, showing yellow fangs." The illustration we have in Power's book does not correspond very well with the representation by Sutherland, which is the picture of Rauparaha most commonly met with, and which is copied from a drawing in Shortland's "Southern Districts of New Zealand." Power's portrait is somewhat like Gilfillan's in outline, and the general shape of the *moko* marking is much the same ; but the drawing has evidently been carelessly made, or the engraver has been at fault. It is possible that the author, W. Tyrone Power, D.A.C.C., may have taken his copy from this very sketch by Gilfillan, for in his preface to his book he acknowledges that some of the sketches used as illustrations were by Gilfillan, and he asks pardon for publishing them without permission specially given. On comparing the drawing with K. L. Sutherland's well-known picture, reproduced in several works, and pronounced by the late Hon. J. W. Barnicoat, M.L.C. (one of the party in the Wairau massacre), to be an excellent likeness, one finds many points in common ; but, as Sutherland's is side face and Gilfillan's three-quarters, the latter naturally shows more of character, whilst any one will see at a glance that in the former the Maori type is not sustained—in fact, one would say that the face was entirely European were it not for the bunch of feathers suspended as an eardrop, and the tattooing. It is very noticeable that Sutherland was not able to grasp the subtle lines of Maori features, for in his drawing of Rangihaeata we have the European cast of countenance again strongly portrayed. The *moko* markings were evidently unfinished on the great chief, and all three pictures give the main outlines much the same ; but in Sutherland's, also, the various markings have been carelessly made, and cannot be compared with Gilfillan's for accuracy. The chief seems to have been wearing the same ear-pendant when both portraits were taken, but it is noticeable that the arrangement of the hair is entirely different in both. In this respect Power's picture and Gilfillan's coincide, but Sutherland's is evidently faulty. Wakefield mentions Rauparaha having sat for his portrait to Major Heaphy, but that gentleman did not publish the result with the rest of his drawings, some of which were issued in a pictorial supplement to Wakefield's "Adventures in New Zealand." Angas, the artist, does not appear to have had any success when he was at Kapiti about 1844. He states in "Savage Life and Scenes" that he failed in his attempt to paint Rangihaeata, so, I presume, thought it useless to try and persuade the superior chief to sit. In Thomson's "Story of New Zealand" it is stated that in 1844 Tamehana Rauparaha had a portrait of his illustrious father hanging in his house at Otaki, but so far as I can gather this picture has never been reproduced. It would be superfluous to give a detailed account of the life of this remarkable man here. Such can be found in the Institute's Transactions, vol. v, in a very fine paper, "The Life and Times of Rauparaha," by the late W. T. L. Travers, or in vol. vi of John White's "Ancient History of the Maori."

Hone Heke, the great chief of the Ngapuhi Tribe, is well known for having cut down the flagstaff at Kororareka, in July, 1844. His life occupies a prominent place in every New Zealand history, and up to the present time there have been three pictures published of him. I can find, however, no description of his personal appearance in any of the books at my command. The best-known picture of Heke is that taken with his wife from a sketch by Merritt, which appears in Thomson's "Story of New Zealand" (vol. ii, p. 96) and other works. The stern, commanding look of the warrior is well portrayed both in this and in Gilfillan's picture, but the former does not correspond altogether with the latter, the whole head being too square, with nose, forehead, and lips too much after the European type. The general *moko* lines are much the same in both, but the nose-markings which appear in Gilfillan's sketch are wanting in Merritt's, whilst the connecting lines between the markings round the lips and the cheek-spirals are different. Of the two drawings, Gilfillan's is the finer, and, being larger, more details are obtained. Another picture of the Ngapuhi warrior is in a water-colour sketch by J. Merrett, in the collection of Dr. T. M. Hocken, of Dunedin, a reproduction of which is given at page 365 of Mr. A. Hamilton's "Maori Art." This is a beautiful drawing of five Natives in full dress, and well delineates the different types and castes of Maori countenance. Here Heke is shown full face, but, although very fine, it does not depict the stern, commanding presence portrayed in Gilfillan's sketch, or in Merrett's other picture in Thomson's work. (Although there is a difference in the spelling of the name "Merrett," the pictures are, I presume, by the same artist.) Yet another picture that we have of Heke is attributed to Angas, and is to be found in "New-Zealanders Illustrated," Heke and Patuone occupying the one plate. This picture is reproduced in "Annals of the Colonial Church" (p. 164), published in 1847, and in several later works, in some of which the word "photo" is placed before Angas's name. In "Savage Life and Scenes" Angas gives a short account of the life of Heke, but he makes no mention of having taken a sketch of the chief, and it is certain that he did not carry a camera around with him. I am inclined to think that the picture has been drawn from memory, or at any rate hurriedly, for it bears the appearance of careless handling in regard to the tattoo-marking, whilst the portrait of Patuone, on the other hand, seems to have had much care bestowed on it to obtain a true likeness. In this latter portrait there seems to be a design in the tattooing which is fairly regular, but there is no suggestion of that in the picture of Heke. Angas's picture is three-quarter face, while Gilfillan's and that in Thomson's work, already mentioned, are both side face, and accordngly it is not easy to make a comparison save by the tattoo-marks. In Angas's the nose-markings show a few irregular curves following no design at all. There is a somewhat indefinite line running from about under the inside of the right eye towards the point of the nose, which line is met about half-way between the eye and the nostril by a curved line running from the inside of the cheek-bone and parallel to the eye. There also appear to be some barely defined markings on the nostril, as well as several lines running away from the nostril and curving round the mouth to the chin, where there are a few marks evidently intended for the completion of the side-face scroll. The picture generally does not coincide with the other two in any particular, and consequently I am inclined to think it has been drawn from memory, if not from imagination. A photograph of Gilfillan's drawing was submitted by a friend of mine to Heke's grand-nephew, Mr. Hone Heke, M.H.R., of present-day fame, who recognised it at once and said that the nose, mouth, and chin tallied exactly with the description that had been handed down to them of the old warrior. He said that he could have recognised it at once from the description his old people had given him. On the whole, therefore, I am practically sure that the picture of Heke I am showing may be relied upon as correct in most essential particulars.

Heke's wife, the beautiful and intelligent daughter of Hongi, well known by his visit to England about 1820, is often mentioned in history, but so far we have had no picture of her, except the one (already mentioned) in Thomson's "Story of New Zealand." Gilfillan's picture coincides with this in every way, as far as comparison is possible, but it is not easy to make this, as the first-mentioned is a side face and the latter nearly full face. The tattooing on the chin, arrangement of the hair, and general features appear to be much the same, but Gilfillan's sketch has the advantage of being larger. It is said that Heke's last days were embittered by the thought that he had no son to inherit the magic of his name, and in the hope of obtaining male issue he contracted an illicit alliance, which was highly resented by his beautiful and attached wife.

Maketu (not to be confounded with the northern Maketu) was the great fighting chief of Wanganui, and as his name occurs in history it is interesting to be able to give his portrait. According to Rev. R. Taylor at page 558 of "Te Ika a Maui," who calls him a great chief, Maketu was shot by a random bullet while engaged plundering during the early war, about May, 1847; but this account of his death may be somewhat incorrect, for it is now known by a few that he met his death from the bullet of an early settler, who, seeing him rocking himself in a chair in Churton's house, deliberately shot him from Churton's Creek. This information was probably suppressed before for various and obvious reasons. Maketu's fishing or village *pa*, Mawhai, which, according to Mr. Fred Parkes (a pioneer of the early days) was fortified, stood on the flat overlooking the site of the present residence of Mr. A. D. Willis, M.H.R., about a mile above the Wanganui town bridge. As before stated, Maketu stood out for a time against the sale of Wanganui to the New Zealand Land Company, when E. J. Wakefield was arranging for the purchase; and at the conference of chiefs at Purua Creek (now known as Durie Creek), where the sale eventually took place, he took a prominent part (Wakefield's "Adventures in New Zealand," vol. i, p. 286). Wakefield is very careful to impress upon his readers that Maketu was not a principal chief; and his reason is very obvious, for it was only natural that he should try and belittle any opposition that he experienced. Wakefield also had a good deal to say about Turoa, whom he cites as being a chief of very great importance; and it is interesting to know that Wakefield's friend Pehi Turoa and Maketu were brothers, or, as some of the Natives tell me, cousins. On looking at a copy of the Treaty of Waitangi I see that Turoa signed his name, and the marks by Williams signify that he was a chief of great importance. I do not find Maketu's name; but, as Wakefield remarks, very few of the Wanganui chiefs did sign, and naturally those who were averse to British rule—as was Maketu—did not. The absence of Maketu's name from the signatures of the treaty is quite understandable. His chief *pa* and land were evidently at Waipakura, some distance up the Wanganui River, from which place he fired at the Putiki canoes bearing the captured prisoners—the authors of the Gilfillan outrage. Strange that Maketu should have his likeness perpetuated by the very man, the outrage on whose family he evidently sympathized with, even if he was not one of the instigators.

Since the above was written, an interesting piece of confirmatory information has come into my possession. I have in the foregoing referred to the evident care with which Gilfillan has depicted the tattooing, and I am now told by Mr. Allison that his aunt, one of the daughters of Gilfillan who escaped from the massacre, has informed him that her father in his Maoris sketches was always very careful to get the tattooing absolutely correct, as the Natives themselves insisted on every line being drawn and put in its correct place. This explains a good deal, and gives Gilfillan's representations an added value as true and faithful depictions of historic personages.

Art. XX.—*The Winged Pilot of Hawaiki.*

By Archdeacon Walsh.

Many centuries before Columbus made his adventurous voyage across the Atlantic, or Vasco de Gama battled his way round the Cape of Good Hope, the Polynesian navigators were sailing backwards and forwards among the countless islands of the Pacific, their operations gradually extending eastward, northward, and southward from their original home in the west until they reached from the New Hebrides to Easter Island, from Honolulu to New Zealand, and covered an area five thousand miles long by four thousand broad. Besides these voyages, it is known that they occasionally found their way back to " Avaiki," traversing a far greater distance; and there is more than one record of an expedition to the Antarctic.

Mr. S. Percy Smith, F.R.G.S., President of the Polynesian Society, in his recent work, " Hawaiki: the Original Home of the Maori," gives an account of many of these voyages, which he has compiled by a comparison of the independent traditions of various branches of the race that have been cut off from mutual intercourse for hundreds of years, and which may therefore be considered as authentic history in all essential details. He also relates how the hardy adventurers managed to keep their course by day and night without the aid of those instruments which are considered indispensable by modern navigators when making even a short trip out of sight of land. He states that it is well known that the Polynesians had a very complete knowledge of the movements of the heavenly bodies, and refers to a statement of the late Mr. John White, that the teaching of astronomy formed a special feature of the old Maori *whare-kura*, or house of learning (" Hawaiki," p. 137). They had also, he adds, in some instances a kind of rude substitute for a chart, formed of strings stretched on a frame, which showed the position of the islands as well as the direction of the ocean-currents and the regular roll of the seas before the trade-wind. A sketch of one of these charts is given on page 139. Following up the subject, Mr. Percy Smith gives a graphic description (p. 138) of how they managed to pick up the land. "When making voyages to a high island or a large one," he says, "the difficulty of a landfall is not great. But it is different in the case of the atolls, of which there are so many in the central Pacific. The system which was adopted in such cases was this: The people generally voyaged in fleets, for mutual help and company, and when they expected to make the land . . . the fleet spread out in the form of a crescent, the chief's canoe in the centre, to distances of about five miles apart on each side, so as to extend their view; whichever crew saw the land first signalled their neighbours, who passed the signal on, till the whole fleet was enabled to steer for the expected land. A fleet of ten canoes would thus have a view of over fifty miles on their front."

Taking these facts into consideration, one can readily understand how these bold and resourceful navigators managed to reach their destination once the direction of their objective and the distance to be travelled were approximately known; but it is not always easy to conceive how the objective came to be determined on. What, for instance, would suggest the idea that there might be land in a particular direction some thousands of miles off, such as that of New Zealand or Honolulu, which might repay a voyage of exploration? Mr. Percy Smith says ("Hawaiki," p. 131) that "in passing onward by way of New Guinea, the Solomons, and New Hebrides to the Fiji Group, the idea must have forced itself into the minds of the people that the whole eastern world was covered with islands, and that they had only to move onward into the unknown to find more lands on which to settle." This was very likely the case in a large number of instances, and it is probable that many of the islands and scattered groups within a certain limit were reached in this way. One can readily understand that in a strong weatherly vessel like their large double or outrigger sailing canoes, which could beat to windward with any topsail schooner, and in which, therefore, they would have no difficulty in making their way back in any direction, they might put out on a voyage of discovery which in the tropical and subtropical belt would be almost sure to be attended with success; but that any party should have been sufficiently hardy and persevering as to systematically sweep the empty vastnesses of the northern and southern Pacific on the off-chance of finding land for settlement is scarcely within the bounds of credibility.

The fact is quite authenticated that long before the great migration to New Zealand—*i.e.*, the advent of the "Arawa," the "Tainui," the "Aotea," the "Mataatua," and other canoes—which is generally placed in the fourteenth century—many vessels found their way backwards and forwards between this country and Hawaiki (probably Tahiti or Rarotonga). An account of several of these expeditions is given by Mr. Elsdon Best in the "Transactions of the New Zealand Institute" (vol. xxxvii, art. ii), but I believe there is no tradition extant as to how the first navigators managed to find their way here, and so were able to give the course to those who followed.

It is related that Ui-te-rangiora, who lived in Fiji about A.D. 650, after making many voyages of discovery and founding colonies in different parts of the Pacific, found his way to the Southern Ocean; and that another celebrated navigator, desiring to behold the wonderful things described by his predecessor, actually penetrated to the frozen seas of the Antarctic—"a foggy, misty, and dark place, not seen by the sun" ("Hawaiki," pp. 128, 129). But beyond the Island of Rapa, or Opara, in 28° S., about eleven hundred miles south-east of Rarotonga, at one time thickly inhabited by Polynesians, there is, I believe, no mention of any land seen on these voyages. In any case it is quite clear that New Zealand was not visited, or the fact would surely have been mentioned in the circumstantial accounts that have been preserved.

We are therefore left to speculate as to how the original discovery of these islands was made. It may, of course, have been that a party were driven out of their course by wind and weather, and arrived here simply as castaways; but it is far more likely that they had something to go upon in fixing their objective.

As already stated, there is, I believe, no tradition that will throw any light on the subject. If a Maori of the present day is asked how the first immigrants found their way to the country, he will either answer that he does not know or that he has never heard, or else he relegates the whole matter to the domain of the supernatural. It was perhaps a *taniwha* that showed them the course—a fabulous monster often credited with more than human powers and intelligence; or it might have been one of their *atuas* or ancestral deities, who, under the form of a shark, a cormorant, or even of a blow-fly, either swam or flew ahead of the canoe, and so led the navigators to their destination.

A theory advanced by the Rev. Wiki te Paa, of Northern Wairoa, inclines one to believe that a core of truth may be contained in this strange myth. It was the annual migration of the *kuaka*, or godwit (*Limosa novæ-zealandiæ*), Mr. Te Paa thinks, that led the Hawaikians to believe that lands existed in the direction of New Zealand, and furnished them with a guide on their voyage; and an examination of the life-history of that wonderful little bird at least gives an air of probability to the idea.

A very complete and graphic account of the *kuaka's* habits is given by Sir Walter Buller in his monumental work on New Zealand birds (vol. ii, p. 40), from information supplied by Captain G. Mair. The learned doctor describes the extraordinary migration it performs every year. Starting in large organized parties from near the North Cape of New Zealand in the end of March or the beginning of April, it makes its way northward, passing along by China, Japan, and Manchuria, until it reaches Eastern Siberia, where it remains for several months and rears its young; the rest of the year being spent in its alternate home in the Malay Archipelago, Polynesia, Australia, and New Zealand—the New Zealand contingent returning in straggling flocks from September to Christmas.

The flight of birds has often helped the navigator in locating a country. In his account of the discovery of Bass Strait in 1798 Flinders describes the continuous stream of sooty petrels or mutton-birds heading in a certain direction, which he took to be an indication " that there must be in the large bight one or more inhabited islands," which eventually proved to be the Furneaux Group. Similar instances are recorded in the history of other voyages of discovery; and it seems to me that an observant and adventurous people like the Polynesians could not have failed to observe the annual migrations of the *kuaka* to and fro between known spots, and that a party of them, driven by some tribal quarrel, or by some urgent necessity to seek a new home, would not have hesitated to trust themselves to the guidance of the winged pilot over the wide seas that separated them from New Zealand. The large number of birds would indicate a considerable tract of country, while the fact that on their southern journey they went in " straggling flocks " extending over several weeks would enable the travellers to check their course from day to day.

A careful observation of the routes travelled by the birds would doubtless throw some light on this theory.

Art. XXI.—*On a Stone-carved Ancient Wooden Image of a Maori Eel-god.*

By A. K. Newman.

[*Read before the Wellington Philosophical Society, 2nd August*, 1905.]

Plate LX.

This quaint figure of a Maori god of eels was dug up recently whilst a field was being ploughed near the City of Auckland. From its position when found, it is clearly of great antiquity. It is a relic of the Stone Age, having been cut by stone chisels, and in its style and character is striking proof of the excellent work done by the prehistoric Maori carver. The body of the eel is carved with great skill, and is exceedingly lifelike. It is carved on a board belonging to an ancient *wharepuni*, or temple.

Maori mythology has many references to eels and eel-gods, and, as will be shown presently, the capture of eels was always celebrated with religious rites and ceremonies by the prehistoric Maori—both before he went eel-catching and after his return.

Tangaroa in New Zealand and throughout Polynesia was the god of fishes. He was one of the greatest of all gods, and so sacred throughout Polynesia that his image was never carved. Tuna was one of the lesser Maori deities, the son of Manga-wai-roa. Legend says there was a drought in heaven, and naturally the eel-god came away in search of water, and came to earth. One legend says he killed two of the great god Maui's children, and the latter in revenge slew him. Another legend says that in Maui's absence Tuna came up out of the water and ravished Maui's wife. Hearing this, Maui told his wife to go to the *whare* by the river, and he laid logs between the hut and the river and there lay in ambush. Tuna came gliding gaily over the logs to see the lady, and Maui slew him. One legend says that Tuna's tail became the fresh-water eels' progenitor, and his head produced salt-water eels. The next story reverses the order, but confirms the fact that he begat both sorts. John White says some Maori tribes worshipped Ruahine as the god of eels, and performed religious rites to him. His worship, however, was strictly limited, as there is no other reference to him in Maori legends.

Religious Rites of Eel-fishing.

When a young man first went eeling the *tohunga* performed many rites over him, and recited appropriate *karakia*, invoking the gods to make him a successful fisher. Eldon Best, in our Transactions of 1902, gives a special *karakia* addressed to Tanga-roa used at this ceremony, which caused a great haul of eels. When a young man made his first catch he gave to his priest an offering of the daintiest—a sign that the Maori *tohunga* knew how to look after his own interests.

Maoris in olden days when building eel pas or weirs put at each end of the weir a carved post, which, like all other Maori carvings, had a religious character, and thereby invoked the eel-deities to make it a success after their labours.

Eel-fisheries were as valuable to the ancient Maoris as gold-mines are to Europeans. The failure of the eel-catch was often a great disaster. In the earlier days when Europeans first came to New Zealand, cuttings from swamp to swamp abounded;

there the Maoris caught the migratory eels. These eel-drains are fast disappearing, and will presently be as extinct as the carved eel-posts, none of which have been saved for our museums.

If a tribe of Maoris owned the lower half of a river and did not dare, because of a powerful tribe, to fish the upper half, they chose a stone or log of wood, calling it a *mauri;* the priest sanctified it; and this was supposed to have the effect, aided by his incantations, of preventing the eels going beyond and thus being lost to them.

Not one of the first catch made by a young man was allowed to be eaten by women. Women in Mangaia must not eat eels.

There was nothing the prehistoric Maori did in relation to the catching or eating of eels that had not its appropriate ceremony or rites performed to the gods. Tangaroa married Te-ami-awatoa (Chilly Cold), and out of this appropriately named lady begat all kinds of fish.

In Mangaia Tuna was an enormous eel, lover of Ina-moe-aitiu. Tuna assumed human form, and the angry deities threatened to drown the world because of this deed. He told Ina to cut off his head and bury it; then the flood ceased. Tunarua was a name sometimes applied to Tuna. Tinirau was the son of Tangaroa, the god of the ocean, and he also was god of fishes. The Mangaians said he was half a fish, and god of all fishes. He was born in spirit-land, and made of flesh torn from his mother's side.

Apparently the different tribes of Maoris worshipped different deities to help them when fishing.

If an eeling expedition failed to catch fish, the Maoris at once knew the gods were angry and it was no use going on trying until they went back to the *pa* and the *tohunga* had gone through fresh ceremonies and appeased their wrath. I was told this story in Wairarapa, where there are bare hills so steep that no vegetation clings to their naked sandstones. They are called *taipos*, or devils. If a Maori went fishing or birding between them in the Maungapakeha Valley, he might fail to get either birds or eels. The reason was that the Tinui *taipo* was angry, and would say to the Maungapakeha *taipo*, "This man has offended me; he shall catch no more eels or birds to-day." That Maori might try as he liked, he got no more that day. After returning to the *pa* and reciting *karakias* he might thus appease the angry *taipos*, and next day they would allow him to catch plenty.

The Carving.

This figure of an eel-god with the head of a man, and this excellently spiritedly carved body of an eel with legs and arms of a man, is quite unique—the only figure of an eel-god in existence in New Zealand. There is no other specimen resembling it. It is 38 in. long by 10 in. wide. The head is very human, with a singularly broad, flat, dome-like forehead. The size of the forehead is the more remarkable because, as a rule, the forehead is neglected in Maori carving. This has the effect of giving the image a look of quite unusual intelligence. It is a forehead denoting great ability, and therefore is quite unlike any modern Maori carving. The mouth, as is usual in a god, is enormous—wide open, cavernous. The tongue is visible, but small, and does not protrude; at each side of the mouth one incisor tooth is carved—as is so often seen in old Maori carvings. The eyes, like those of all ancient Maori gods, are slanting—Mongolian. The nose is very flat. A thin line of tattooing is on each eyebrow, all over the nose, and a thin single ring surrounds the gaping mouth. This tattooing, as shown in the plate, is simple, and is evidently the work of stone and not iron chisels. The figure has two arms and two legs, each arm with three fingers and each leg with three toes—the one unfailing, universal mark of a god. Three fingers or three toes on each limb, a wide-open mouth, and slant eyes are unfailing symbols of the prehistoric Maori deity. The limbs, too, are tattooed with the double spiral. At the point of the right elbow and right knee (the left elbow and left knee are omitted from the carving) is a curious hollow, and from the ends of each hollow is a curious tattooed little figure like an inverted capital C, and at the junction a quaint little knob. What this means I do not know. Something like it is seen in other Polynesian images. Arms and legs are covered with tattooing, chiselled out, but not fine and blackened as in modern carvings.

The Body.

The remarkable feature is the raised, sinuous, lifelike body of an eel, fat and big, arising from beneath the chin. The head is aslant, looking over the left shoulder, as seen in many *heitikis*. As the eel-like body then turns first to the right it may have been thus carved to give another turn to the sinuous look of the eel; but it may have been turned to the left shoulder for the same reason as *heitiki* heads are made to turn—a reason unknown to us. The body, like that of a real eel, is fat and round, and quite smooth, free from any trace of ornamentation. There is no tail; the body ends abruptly where the legs are set on, and at the end of the body is a hole going right through the board on which the figure is carved. This probably is meant for the anal and other apertures.

Summary.

As a specimen of a Maori eel-god it stands alone ; it is unique. Mr. Hamilton showed me a figure in the Museum of a Maori god with a strange burly figure representing some unknown animal object, but certainly not an eel. A god with an eel-like body was worshipped in Samoa, and that is the only god I have found anywhere resembling this.

It is not surprising that Maoris should have carved an image of the god of eels, as they had so many religious rites in connection with eels and eel-fishing; but it is singular that so far this is the only image of an eel-god discovered, and therefore, doubtless, even among the ancient Maoris, such a figure was very rarely depicted. Tinirau, god of fishes, was described as being a merman—"half man, half fish"; and this figure of an eel-god is embodied in this figure—half a god and half an eel.

Art. XXII. — *On the Musical Notes and Other Features of the Long Maori Trumpet.*

By A. K. Newman.

[*Read before the Wellington Philosophical Society, 2nd August,* 1905.]

This 5-ft.-long black Maori trumpet was made either by the Arawa or by the Tuhoe Tribe. They were always extremely rare, and only a few exist in museums. I have asked Mr. Warren, an expert bugle-player and accomplished musician, to blow this trumpet for me to-night. [Mr. Warren here played a number of British and other army bugle-calls upon this instrument, fashioned by savages; and on another occasion to a gathering of musicians, to the manifest pleasure of the audiences.] Experts declared that its tones were so clear and good that had they not seen the instrument they would have believed the sounds were made by a modern silver bugle.

Unlike the mouthpiece of a modern bugle, which is small and round, this is a long, wide slit, and Mr. Warren found it difficult to get his lips into shape. He suggests the opening was made to suit a wide-mouthed 17-stone Maori. He found it in consequence difficult to play long calls, and not until he had taken it home, lived with it, and practised with it for some time was he able to get the full tones out of it. Blown by a big-chested Maori giant, the sound of this instrument would travel an enormous distance.

I was anxious to learn what calls the Maoris played, but this is impossible. Many modern Maoris have never seen this *pukaea ;* rarely indeed has it been blown of late years. It is probable that beyond one or two Maoris (and even this is doubtful) no one could sound it. I ransacked the Maori literature in the libraries, and find it rarely mentioned. My friend the great Maori expert, Mr. Samuel Locke, had one, and this is an exact replica of it. Mr. Colenso says he had only seen one or two in the early days, and greatly prized the one Mr. Locke had. Mr. C. O. Davis jotted down a few Maori tunes, and so did a musical expert for Sir George Grey, but these are for Maori flutes.

Colenso quotes the following interesting passage from Forster, the naturalist, who came to New Zealand with Captain Cook: "They brought a trumpet or tube of wood, 4 ft. long and pretty straight. Its small mouth was not above 2 in. wide, and the other not above 5 in. in diameter. It made a very uncouth kind of braying, for they always sounded the same note, though a performer on the French horn might perhaps be able to bring some better music out of it." Forster wrote these words of prophecy, and to-night, 130 years later, Mr. Warren has shown you how wide is its range, how musical and perfect its tones. It is interesting to note that Forster says the Maoris uttered an uncouth braying sound. Mr. Warren makes it utter any musical bugle-call. The difference is that Mr. Warren knows the tunes and the Maori did not. Much of Maori art and Maori carving is simply a degradation of a higher past. Their ancestors in far-past days invented this instrument, and doubtless could play it for all that it was capable of; but their descendants forgot their ancient musical lore, and as time rolled on their knowledge shrank and shrank, till it was, as Forster writes, always the same note—an uncouth braying. The Maoris in Forster's day could not produce the varied notes that were lying dormant. Having old trumpets in their possession, they could easily copy them ; but how to produce the old notes and tunes—the memory had lapsed.

Judge Chapman, the learned expert in Maori art, told me this strange story : Years ago an ancient Maori said that his ancestors in the far past had played on a trumpet that worked in and out of its tube. The Maori explained how it was lengthened and shortened, as Judge Chapman says, like a modern trombone. The Judge believes that this must have existed in the long-ago ; but there is not one left for our museums.

One old writer says they shouted words through it. This is incorrect. Mr. L. Grace says the chiefs had a few well-known calls.

John White and the Rev. R. Taylor do not mention or describe this trumpet. Colenso says the chiefs when travelling were known by their trumpet-calls. When a great chief travelled he sometimes ordered the trumpet to be sounded, and the distant villagers in the *pa* at once cooked food for the war-lord and his war-bands. Locke, in these Transactions, in 1882, gives an interesting account of a chief who thus announced himself, and how such announcement led to a devastating war.

Pukaea.

Williams, in his dictionary, says this was a long trumpet made of *totara*. Tregear says, *pu* = to blow, *kaea* = to wander forth. A " blow " that carries far is an apt name for this instrument; that blown by an excited burly Maori would carry for miles. *Putara* is a conch shell with mouthpiece used as a trumpet, and *putorino* is a nasal flute. *Puroraiti* was a trumpet used at the *marae* in Samoa. It is noteworthy that *putatara* (conch-shell trumpet) is a capital word, so like the instrument: *pu* and *ta-ta-ta-tara* is an accurate copy of the notes " ta-ta-tara " which Mr. Warren has just drawn out of this *pukaea* for your pleasure.

These trumpets were always made of durable well-dried *totara*, beautifully fitted together, and bound tight round from nozzle to within 3 in. of the other end with supplejack very tightly and neatly laid round it, each layer closely touching its predecessor. Colenso says the joinings of the *totara* were closely cemented together by a native gum. The supplejack binding held the *totara* limbs together.

At the point where the long narrow tube widens into the funnel, transversly athwart it inside are two narrow pegs of wood. Tregear says the Maoris called this *tohe* (*tohe-tohe* is the uvula). In looking through the trumpet more towards the sunlight I discovered a third peg about 6 in. from the mouthpiece. The presence of this third *tohe* is, I believe, a new discovery. I have seen no reference to it in Buller's or Hamilton's works or elsewhere. The presence of these three *tohe* is curious. Doubtless they affect the tune of the instrument. They may not exist in all trumpets.

Rarity and Uses and Antiquity.

These trumpets were always very rare—confined in manufacture to the Hot Lakes district, though doubtless carried rarely to distant parts. Hamilton, in his great work on " Maori Art," photographs several in museums: one with two funnel-shaped trumpet-ends arising from the same tube. Colenso said they were so rare that when he saw Locke's trumpet twenty years ago he had not seen one for twenty years previously; and as Colenso was here as far back as the " thirties " of the last century, it is clear how rare they were. They were used as alarms in war-time, to tell of threatening danger. They were also used as announcements of the march of great chiefs, just like war-lords and medieval heralds. They were used for the same purpose as army bugle-calls are nowadays. When the ancient Maori at night was scared of attacks by ghosts, he shouted and played the conch-shell trumpet and this *pukaea* to frighten away the spirits. In Samoa, and perhaps other islands, they were used in the sacred *marae* in religious ceremonies.

Tregear, in the "Aryan Maori," quoting from the Indian Bhagavad-gita, gives a description of a fight by the Kurus: "Then, in order to encourage him, the ardent old ancestor of the Kurus blew a conch shell sounding loud as the roar of a lion. He of dreadful deeds and wolfish entrails blew a great trumpet called *paundra*." Our Maoris, having originally come from India, doubtless derived their trumpets from their ancestors. It is noteworthy that the conch shell and the long trumpet of the Maori were both known thousands of years ago in India, and the nasal flute of the Maori was brought from the ancestral home in Asia, as we know it existed there and in Greece. The conch trumpet and also the long trumpet were each named in this story of India, and Maoris continued this custom, having a name for each important *mere* or *taiaha*, or noteworthy canoe-baler, or big trumpet. These long trumpets clearly did not originate *de novo* among the Maoris, but were brought by them from their far-off continental ancestral home.

Darwin traced the descent of man by studying, amongst other things, the rudimentary organs in the modern human body. So to-day we, by studying the Maori, can see many objects of Maori art which, like rudimentary organs, serve to show the descent of the Maori. Among these are the three fingers carved on the hands and three toes on each foot of a Maori god or semi-deified ancestor, seen in India; the little red stones (*whatakura*) worshipped by the Maoris were worshipped in India; the double spiral in Maori carving, the double-toothed earring of jade (both symbols of Buddha and of far earlier deities), the lighting of sacred fires by rubbing sticks, and the curious figures Mania and Marikihau, all are to be found in India.

This trumpet played to you by Mr. Warren is itself a direct descendant of the *paundra* blown by the Indian chief. As the trumpet has a limited range, the bugle-calls sounded by the great Indian chief ("he of dreadful deeds and wolfish entrails") were much the same, though blown thousands of years ago, as those to-night played for you by Mr. Warren, who has done no dreadful deeds, and certainly has not wolfish entrails. But the old Indian chief, the Maori *rangatira*, and Mr. Warren are, after all, blood relations, for the Hindoos, the Polynesians (including the Maori), and Mr. Warren are all three Caucasians, all three have trumpets, and all three use the same instrument for the same purposes.

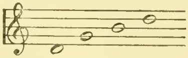
Notes on Dr. Newman's Maori Trumpet.

By W. H. Warren.

I may say at the outset that, owing to the peculiar oval-shaped wooden mouthpiece, which is very rough on the lips, it is well-nigh impossible to produce any of the lengthy bugle-calls, such as the "Reveille" and "First Post," as can be done with comparatively little effort on the regulation B-flat bugle.

The tones that the instrument gives out are very similar to those of a bugle, but it cannot be made to produce the lowest C of the *pakeha* instrument. Such calls as the "Dress for Parade," "Rouse," and "Last Post" cannot, therefore, be played in their entirety.

The staff notation of the Maori instrument is :—



and that of the B flat bugle :—

It will thus be seen that the Maori trumpet is capable of producing four notes. The lowest, however, is hardly as clear as the G of the brass bugle, and the lips of the performer require to be in exceptionally good form to produce with any degree of success its highest note. The two middle notes, G and B, can be produced with exceptional clearness, and are, in fact, far more pleasant to the ear than the C and E of the brass instrument.

Appended is a list of the calls which are most suited to the Maori trumpet, which when sounded would assuredly astound the average regimental sergeant-major when that portly non-commissioned officer was asked to believe that the tones did not emanate from the military bugle in every-day use.

LIST OF CALLS SUITED TO THE MAORI TRUMPET.

Officers.	Sick call.
Sergeants.	Salute for guard.
Fall in.	Alarm.
Men's dinner call.	Charge.
Sergeants' dinner call.	Fire, and Cease fire.
Fatigue.	Extend, and Close.
Picquet.	General salute.
Orders.	

ART. XXIII.—*On Temporary Stars.*

By MARTIN CHAPMAN.

[*Read before the Wellington Philosophical Society, 6th September*, 1905.]

THE appearance of a so-called temporary star is always an event of great importance to all interested in astronomy and its kindred sciences. The event apparently involves a catastrophe of such colossal magnitude that it almost transcends our powers of imagination fully to realise it. A star which perhaps to our view is so insignificant as to be visible only in a powerful telescope—say, of the tenth or twelfth magnitude, or perhaps not visible at all—suddenly increases in splendour until it shines as a third- or second- or indeed even first-magnitude star. If our sun were to increase in heat- and light-giving activity in a similar proportion there can be no doubt that all planets would be rendered red- or white-hot, if they were not dissipated into vapour.

After this enormous development of light and heat the new star in a few days or weeks shows manifest signs of waning. This waning proceeds so rapidly that at the end of a few months the star is no longer visible to the naked eye, and can only be perceived through powerful telescopes. Its final appearance is also remarkable: it presents the appearance of a planetary nebula—that is, it appears to be a nebula of no great intensity of light, having a minute disc like a planet; but the fact that it has any visible disc is a proof of its colossal dimensions. No "Nova" has, so far as I am aware, yet shown an appreciable parallax: it follows that to have any disc visible to us its diameter must exceed that of the earth's orbit.

That such a vastly colossal globe of glowing matter should part with its heat in a few months is at first sight exceedingly surprising, and has led to the suggestion being made that the actual quantity of matter heated must be very small. How otherwise, it may be asked, can it be? A body like the sun is unaltered, so far as we can tell, after thousands or millions of years of cooling. How long, then, ought a body take to cool which can shine as a star of the first magnitude though so far distant as to have no measurable parallax ?

I have to consider this question, and show that the rapid cooling of a "Nova" is a necessary consequence of the added heat, from whatever cause due, and will take place though the body be equal in mass to, or greater than, the sun.

Consider a star of dimensions and mass comparable with those of the sun, and assume, as is generally supposed, that the whole is in a state which may be termed gaseous—that is, the temperature is so high that every part responds to increase and diminution of pressure in the same manner as a gas does. It is not necessary to assume that the ratio of expansion to increment of heat follows the law of gases. I make the assumption of the gaseous nature of a "Nova" because, first, there can be but little doubt that a "Nova" at least is in this state, and, secondly, because my arguments have no application to a solid or non-gaseous star. Assuming, then, the star to behave as a gas, we may also assume that at any moment it has such dimensions that an equilibrium exists between the tendency to expand and that to shrink. Each particle will at that moment be solicited by two forces—one the attraction of the mass, which tends to draw the particle towards the centre, the other the expansive force due to the high temperature of the gaseous mass. These opposing forces must exactly neutralise each other to produce an equilibrium. If there is any disturbance of that equilibrium the particle will move towards or away from the centre according as the gravitation or the expansion due to heat is in excess. In the case of the sun the equilibrium is being disturbed from moment to moment by the continuous radiation away of heat.

Consider the effect on a particle : Heat is radiated away, the amount of heat available to balance gravitation is diminished ; but by the hypothesis the heat before radiation was exactly sufficient to balance gravitation ; there is therefore after radiation an unbalanced tendency towards the centre, and the particle must take up a new position nearer the centre. This must also be true of every other particle of the sun's mass : in other words, the whole mass must shrink through loss of heat radiated away. So far this accords with our experience : a gaseous body—*e.g.*, steam—contracts as it parts with its heat.

Now, at first impression it might be supposed that, heat having been parted with, the sun's temperature would be lowered. It would be so if the volume remained constant, but this is not so ; as shown above, the volume diminishes, and the very fact that the volume diminishes is in itself a cause of the generation of heat. Each particle in moving to the centre obviously falls; in falling it gives out energy; that energy appears as heat.

To change the mode of statement: Each particle approaching the centre constitutes a compression of the whole mass, but the temperature of a gas rises when it is compressed: the temperature of the sun therefore rises. The extent to which it rises is governed by the circumstance that an equilibrium is again sought. But our particle, having fallen, is now nearer than it was to the centre; its gravitation is therefore increased; its tendency to continue to fall requires now a greater force to balance it: in other words, to preserve equilibrium the temperature must be higher than before. The additional temperature is derived, as pointed out, from the compression of the mass. Hence we have what may appear to some a paradoxical result—*i.e.*, that by abstracting heat from the sun (by radiation) the temperature is caused to rise and not to fall—contrary to our experience of cooling bodies. In reality there is no paradox. Part of the heat is due to the contraction.

There are two kinds of energy in the sun, one heat, the other energy of position or potential. If we take away some of the former we, so to speak, call for contribution from the latter, and that contribution is on a scale a little more liberal than necessary to merely compensate what is taken away. The abstraction of heat causes shrinkage, and the shrinkage causes the development of more heat than that abstracted. This is capable of exact calculation, it being known that a shrinkage of about one-eleventh of a mile will account for the radiation of the sun for a year, and (if the sun is gaseous throughout) still leave the sun a trace hotter at the end of the year than it was at the beginning.

The apparent (not real) paradox is exactly analogous to that arising in the case of a secondary body moving about its primary. Supposing a secondary were moving in a resisting medium, which at first sight might be supposed to diminish its velocity, the real observable effect would be that its velocity would be increased through its fall towards the primary. The evidence of a resisting medium, supposed to be furnished by Encke's Comet, is not that its velocity diminishes, but that it increases.

Now, I took the case of heat being abstracted because it is what is going on in the case of the sun, but the whole process above indicated is reversible.

Supposing, again, the star in momentary equilibrium kept so, as before, by gravitation tending to draw each particle to the centre, and the expansive force created by heat balancing gravitation. Now let heat be added: in the first case the subtraction of heat by radiation left gravity partly unbalanced; now the addition of heat leaves the expansive power partly unbalanced. Each particle must therefore move outwards, but in doing so it moves against gravitation work being done and heat absorbed ("rendered latent" was the old expression); but, as a compressed gas heats by the transformation of work into heat, so an expanding gas cools by the transformation of heat into work (both processes being made use of in our steam-engines, freezing-engines, &c.). The added heat then does work against gravity, and is all absorbed in doing so.

Now, if this were all, we should have simply expanded our sun at the original temperature. But when expanded to the extent referable to the added heat each particle is further from the centre than it was before heat was added; gravity is therefore diminished; and since, by the hypothesis, the amount of heat was previously exactly sufficient to balance gravity, there is now more than enough to do so, so that there is a residue of expansive power still left: more heat than that added will therefore be used up in expanding the body. This must be at the expense of the heat already possessed by the sun: in other words, the temperature will be lowered. This is the same apparent paradox, in an inverted form, that we had before: by putting heat into a gaseous star we lower its temperature.

We may put the results alongside each other thus:—

(1.) The body parts with heat by radiation: it *shrinks* in consequence, and the *temperature rises.* We may add, the potential falls to the exact extent of the heat radiated away, plus the added temperature.

(2.) The body has heat supplied to it: it *expands* in consequence, and the *temperature falls.* We may add, as before, the potential rises to the exact extent of the heat added, plus the latent heat of expansion.

Now, let us apply these considerations to a "Nova." Some cause which we can only conjecture occasions an enormous amount of heat to be added to a body. The only probable cause we can think of is a collision of some kind—it may be of two large bodies, or two meteor-streams, &c. If the body was already gaseous the above reasoning would apply at once. If it were not gaseous the added heat caused by the collision (in the case of a "Nova") is sufficient to make it so, and the reasoning will apply as soon as it is so. If the heat were due to collision, as is probable, the process of heating would be exceedingly rapid. If the colliding bodies were both gaseous the generation of the whole heat of collision would take a few hours only; but as the whole of that heat could not be converted in the same time into motion of expansion, because of the inertia of the mass to be moved, the temperature would rise enormously beyond what it would ultimately be on the establishment of an equilibrium. Hence it is quite in accordance with what we ought to expect if, on a collision between two bodies, the temperature should rise in a few hours or days so greatly that the joint mass would shine as a bright star. But this state of things could not be permanent, as the gravity of the mass would be insufficient to counteract the expansive force created by the enormous accession of heat. The mass would therefore expand, the rate of expansion being slow at first, increasing to a maximum, and finally dying out. The body would then be enormously diffused, but at a moderate temperature. The greater the velocity of the impact the lower would be the final temperature. A velocity can be assigned at which the body would be dissipated in infinite space, and the temperature exactly zero; but this velocity could not be acquired by the mutual attraction of the colliding bodies. With any velocity which we can admit as probable the final state of the mass would be a globe vast in proportion to the sum of the original volumes of the colliding bodies, with a moderate temperature. Such a body would present the appearance of a planetary nebula.

Before this final stage was reached there would be fluctuations. The outward velocity communicated to the gaseous atoms would cause the first expansion to go beyond equilibrium; indeed, the outward velocity at the position of equilibrium would be a maximum. Hence the body would be overexpanded and overcooled. It would then condense again, with a rise in temperature again overcompensated. This might, indeed would, be repeated many times, finally dying out. These pulsations appear to have been observed.

The consideration applied here to two colliding globes would equally apply to colliding flights of meteors, but the effects might not be so marked—the rise in temperature would be more gradual. They would also apply to the case of a sphere plunging into a vast hydrogen region, such as the spectroscope reveals to us.

Art. XXIV.—*Notes on a Meteoric Appearance.*

By Martin Chapman.

[*Read before the Wellington Philosophical Society, 2nd August,* 1905.]

I think it as well to put on record a remarkable phenomenon which was observed by myself, with many others, on the evening of the 9th June. A party of us left Otaki by the evening train leaving Otaki about 6.10 p.m. The western sky was clear generally, but with a bank of clouds extending from the mainland over Kapiti ; wind S.W. and fresh. There was a young moon. I was sitting on the western side of the carriage, looking out at the window. I turned for an instant to speak to a companion, and, on returning my gaze to the sky, I saw the appearance about which I write.

It was a brilliant vertical streak in the north-western sky, having a slight feathery wisp at the top, the upper part having two slight bulbous expansions. Its lustre was apparently that of a white-hot wire. I uttered an exclamation which brought all the occupants of the carriage to the windows. We watched the appearance and saw it gradually change in shape. The branch or wisp at the top extended, as did every part, both longitudinally and in breadth. It was visible to us for about a quarter of an hour, and finally disappeared behind a cloud. It was even then quite white, whereas all the clouds were inky-black. It appeared to the last to shine with its own light. The passengers in the other carriages also saw it, and some, I was informed, became strangely excited, two ladies showing fear and symptoms of hysteria. Curiously, a similar report comes from Auckland: some people manifested alarm. By the great majority, however, of those who saw it it was regarded as an object of interest and beauty. Those in the carriage where I sat who had seen waterspouts (of which I was one) agreed that at one stage the streak resembled the slender streak of bright light which is often seen as a waterspout finally disappears; but this streak was (1) much too brilliant, (2) much too minute, (3) much too high for such an explanation. I tried to form an opinion of its altitude and azimuth, but from a train going some twenty miles an hour over a line with curves this is no easy matter, and no reliance can be placed on such a determination. It, however, helps to form an estimate of the accuracy of other determinations. I thought the azimuth would be between 305° and 320°. I guessed the altitude at about 16°, but I had no horizon in view.

The apparition was seen from other stations. At Hokitika it was seen "in the north-western sky." At Nelson it was seen by many persons. One observer, Miss Bertha Maguire, an artist, showed an intelligent and artistic appreciation of the phenomenon ; she sketched the object as she saw it, and her sketches so accurately represent what I saw that it is hardly necessary that I should exercise my feeble sketching powers. The differences between Miss Maguire's sketches and what I saw are small, and consist of the following : I should represent the streak (1) as being more slender, (2) as having a little wisp at the top, and two slight bulbous swellings near the top, the beginning, perhaps, of expansion. By Miss Maguire's kindness and courtesy I am able to show you the original sketches. It was seen from Otaki, Wanganui, Halcombe, New Plymouth, Waiuku, and Auckland. The times from all these places agree, and also the description, except that some of the details are wanting from New Plymouth, whence the sketch is of two balls of light with an intervening streak of light.

The following azimuths have been given: Hokitika, "in the north-western sky"; Nelson, two observers 292°, and a third observer 315° magnetic; at Wanganui an observation was taken at a very late stage of a wisp of the cloud, the bearing being 295°; New Plymouth, 310°; Waiuku, exactly above where the sun set (299° 16′ true). From Auckland three bearings are given: one, 358° magnetic, is an obvious mistake, and probably a clerical error. The second is 243°, said to be by observation with a prismatic compass: this being magnetic would give 258° true. The difference between these two is over 100°, quite beyond personal error. The third Auckland bearing is inexact—"to the south of west." There is also an azimuth from Otaki—W.N.W., or 303° 45′. These discrepancies may partly disappear when we learn which observations are "true" and which "magnetic."

There is a like discrepancy in the observations for altitude. Even three observations from the same place are discordant. The altitudes given are from 10° to 40°. Of course the real altitude would not be the same for different places, but one would like agreement between different observations from the same place. The New Plymouth observer, Mr. Palmer, a surveyor, gives 35°. My guess was 16°. The Otaki observer puts it at 12°. The Otaki altitude ought to coincide with whatever is correct for Waikanae. Mr. Buckeridge, of Auckland, gives "15°, taken with a Barker's altitude instrument." Two sheets of paper, which I will call "A" and "B," were sent me from Nelson, with the angles drawn as follows: Horizon to bottom of streak—A, 3° 30′; B, 6°: horizon to top of streak—A, 10°; B, 17°. Another Nelson altitude is 30°. No hypothesis can be formed which will reconcile all these; we can only hope to eliminate the bad ones.

The total length of the original streak is reckoned as between 6° and 10°, expanding to 15°, or perhaps 20°—*i.e.*, from top to bottom, not following windings. The total length of the ribband of cloud, following windings, might reach 35°, or perhaps more. The breadth at the beginning, as I saw it, was minute, and the light so strong that the apparent breadth may have been due to irradiation. The breadth at the end of a quarter of an hour was nearly, if not quite, 2°. These quantities are eye estimates, corrected by comparison with others, and by using an instrument on an imaginary representation—not a satisfactory proceeding. The figure gives some idea of the magnitude of the object.

Several persons claimed to have seen the very beginning. One, at Auckland, says it shot up from the horizon at an angle of 70° or 80° to a height of 40°. I feel pretty sure the shooting-up is erroneous; also, from my station the streak appeared vertical. Another observer, Mr. A Scott, Auckland, said it "darted out of a cloud like a ball of silver; after dropping a few yards it just for an instant threw off coloured lights, like a rocket, and then left a pillar of silver light as it dropped to the earth. The bright perpendicular column, which remained perpendicular for nearly a minute, made quite a weird impression, till it began to be blown about by the wind. The silvery light would remain for about ten minutes."

Miss Maguire, the artist, whose name I mentioned above, says her impression is that her eyes were directed to the exact spot of the sky at the moment the object appeared. I see no reason to doubt this. If a person's eyes are directed to a point in the sky, and an intense gleam of light appears in the neighbourhood, the eyes are instantly drawn to bear on the spot where the gleam appears. Miss Maguire says her first impression was a flash of "crinkly lightning." Another observer at Nelson says he saw a ball of light fall and burst.

Mr. F. G. Gibb, of Nelson, a person of scientific attainments, whose observations are entitled to great weight, wrote to a newspaper describing what he saw. He says, "The sky was clearly visible at the time, and the 'streak of lightning frozen' remained clearly visible for about half an hour, though an observer who was well situated declares that the luminous cloud into which the streak resolved was visible for two hours. I turned a 5 in. refracting telescope upon the streak within a minute or two after the fall of the meteor, and found that it consisted of long-drawn-out wisps of luminous cloud, which had, I am almost sure, a slight movement downward. The direction in which it appeared from the Town of Nelson was exactly north-west magnetic."

The description by Mr. Palmer, of New Plymouth, differs surprisingly from all others. He says he first observed a luminous head, and afterwards another ball of light also appeared lower down. This latter shape it kept for about ten minutes, and then finally dissolved. His sketch is of two balls, one above the other, not quite vertically, connected by a thread of light, which is prolonged beyond the lower one.

My own first view must have been some instants (hardly seconds) after the commencement. What I saw was a streak of intense white light, with two small bulbous expansions near the top, these expansions forming the brightest part; also a very small feathery expansion at the very top.

I am now trying to work out the distance, a simple enough problem given accurate observations; but, unfortunately, there are such discrepancies in the observations that the first business is to find out and eliminate the incorrect ones—no easy matter.

It is a source of great pleasure to me to have to record this interesting phenomenon, the more so because, so far, it would appear that the occurrence was absolutely unique. No such phenomenon has, to my knowledge, ever been recorded before. Great meteors have often been seen and recorded, and then partly calculated. I had the pleasure of seeing one of the greatest on record—one that gave more light than the full moon, which passed over an arc of 90° or more, and left a glowing train, 30° or 40° long. But that train was gone in a few minutes. Yet this object seen by us left a train which was still shining brightly at the end of fifteen minutes, and was seen for another fifteen, and perhaps even, as some say, for hours. I think I am justified in saying that those who saw it saw something the like of which has never been recorded.

Since writing the above I have made inquiries in the hope of reconciling the wide discordances of observation. I regret, however, to say my attempts have been vain. This being the case, it is useless to attempt to fix the exact position; however, by graphical methods, selecting those measurements of the position of the head which appear to me most satisfactory—namely, Auckland azimuth, 258° true, altitude 15°; Nelson azimuth, 330° true—I find this would seem to show that the head of the streak was probably over a spot something like three hundred miles about W. by S. from Auckland—*i.e.*, over the Tasman Sea. Its altitude above the earth was something like seventy miles for a minimum, and may have been over a hundred. If the brilliant streak was vertical it was about seventy miles long, but as it was probably seen very foreshortened it was probably many times that. The riband-shaped cloud was several times as long as the bright streak, but I do not think this was due to an actual lengthening, but rather to the fact that previously invisible vapour in the track of the meteor became visible by cooling. The widening of the streak from a mere thread to a band some 2° wide was probably chiefly due to expansion. It would appear to have had a final thickness of some miles. This would indicate either a considerable breadth for the meteor or a prodigious temperature, perhaps both. In my opinion the meteor was not one solid mass, but a group of many small bodies, probably derived from the splitting-up of a large mass. Apparently it must have met or been overtaken by the earth, as its course was from east to west. As the streak did not appear to reach the horizon, I conclude that the meteor did not reach the earth. It either passed through a segment of the atmosphere and away, or it was dissipated by its passage through the air. The drawing shows the appearance of the streak at the end of a quarter of an hour, as drawn by Miss Murphy. The appearance at first would be represented on the same scale by a steady vertical line about the length of the top coil.

Art. XXV.—*Maori Eschatology: The* Whare Potae (*House of Mourning*) *and its Lore; being a Description of many Customs, Beliefs, Superstitions, Rites, &c., pertaining to Death and Burial among the Maori People, as also some Account of Native Belief in a Spiritual World.*

By Elsdon Best.

[*Read before the Auckland Institute, 6th December,* 1905.]

"Even as the moon dies, and then, having bathed in the waters of life, returns to this world once more young and beautiful, so let man die and revive." Such were the words of Tane, offspring of Rangi, the Sky Father, and Papa, the Earth Mother, to Hine-nui-te-Po, Goddess of Death and Hades. But Hine of the Dark World said, "Not so. Rather let man die and return to Mother Earth, even that he may be mourned and wept for." Hence we see mourning parties of the Maori people wailing for the dead. For what said the men of old?—"By tears and lamentation alone may [a natural] death be avenged."

Having collected some few notes anent Maori eschatology from members of the Tuhoe or Urewera Tribe, it behoves me to put such together in the form of an article, for the purpose of preservation, so as to place on record any hitherto unpublished matter which they may contain, inasmuch as the "weeds of Tura" have already come to me, and no man may know when he may drink of the waters of Tane-pi and lift the trail of Maui of old for the realm of Miru and of Hine.

Although my notes on some items are sufficiently numerous to give a fairly good idea of Native customs in past times, yet those pertaining to the ritual of burial and exhumation are decidedly meagre. Of the many incantations used on such occasions in the days of yore I have collected but few. This does not, however, affect the general reader, for such matter interests the specialist alone—he who seeks to understand the archaic expressions contained in such cryptic effusions of the ancient Maori.

These notes have been collected from the descendants of the original people of that part of the Bay of Plenty district lying between Whakatane on the coast and Ruatahuna in the interior. My reason for using the past tense in this paper is because many of the customs herein described have fallen into disuse, while others again have been modified since the introduction of Christianity.

A considerable amount of interesting information anent these matters may be found in the writings of the late Mr. John White, Taylor's "Te Ika a Maui," and other works.

The matter contained in this paper is given as collected from the old men of the Tuhoe Tribe of Maoris, and is not made to support any pet theory of my own; for I hold that we who dwell in the dark places of the earth should confine our attention to placing on record original matter only, and carefully suppress any desire to theorise or generalise.

Mythical Origin of Death.

In perusing ethnographical works we often meet with the statement that certain primitive peoples or races appear to be or have been imbued with the idea that death is unnatural; that in the dawn of time man was immortal, and knew not death until it was introduced by some accident, or offence committed against the gods. Among such peoples are invariably found singular myths to account for such introduction.

The Maori of New Zealand come under the above heading, as will be shown anon. In studying Maori cosmogony and anthropogeny we are first met with the statement that man is descended from immortal personifications—*i.e.*, from Rangi, the Sky Parent, and Papa-tuanuku, the Earth Mother; also that from the same source sprang the sun, the moon, and the stars, who are termed the "*whanau marama*" (the Shining Ones, the Children of Light, who know not death). In the words of an old Native, who was explaining to me the origin of death, "The people of the sky [*i.e.*, the heavenly bodies], they do not decay, neither do they fall; they are not like the people of this world. As for the origin of decay among the people of this world, it was caused by the act of Tane in seeking the female element. Rangi, our parent [the Sky] said to Tane, 'The female element is below. Above is the realm of life, of immortality; below is the realm of death, of decay, of misfortune.' Hence, through that quest of Tane, came decay into the world. Had he not sought the female element, then would man have been like unto the multitude in the sky above—he would have lived for ever."

Here we see that the Maori traces his descent from a primal pair, Sky and Earth, the male and female nature respectively, and also that the deathless Shining Ones, the heavenly bodies, had a similar origin. He saw that all these were immortal—"they do not decay, neither do they fall"—hence something must have happened in the dawn of time which caused man to decay, something that caused death to enter the world. The mind of the primitive Maori was equal to the task of explaining that cause. He evolved the myth of Maui and the Goddess of Death. The dead person is often referred to in funeral speeches as having been caught in the snare of Hine-nui-te-Po, the guardian of Te Po (Hades, the realm of darkness), she who drags men down to death. It was this Hine who first proposed that decay and death should be the lot of man (see first page of this article), and her proposal was opposed by Tane, or, according to some authorities, by Maui. "In regard to natural decay and death, it was proposed by our ancestors that man should die as the moon dies; for when the moon wanes and comes near to death he hies him to Te Wai-ora-o-Tane [the life-giving waters of Tane], in which he bathes and so recovers his youth and strength. Our ancestors said, 'Let man so decay and revive, that he may return to this world.' But Hine would have none of this. She said, 'Not so; for man would not be mourned. Let man die as earth-born creatures die; let him return to our Earth Mother, even that he may be mourned and lamented' ('*me matemate a one, kia mihia ai, kia tangihia ai*')." Then came the struggle between Hine and Maui, the attempt of Maui to gain eternal life for man being thwarted by the Goddess of Death.

An old-time saying of the Maori people (published by Sir George Grey in his "Maori Proverbs") is this—"*Me tangi, ka pa ko te mate i te marama*"; which he translates, "Let us weep over him; he has departed for ever; if he had disappeared like the old moon we would not have mourned—he would have appeared to us anew after a time."

MYTH OF MAUI AND HINE-NUI-TE-PO.

Maui is perhaps the principal representative of the age of heroes in Maori mythology, being one of the demi-gods who performed wondrous deeds in the misty past, when man was young upon the earth. It was Maui who procured fire for mankind, who lengthened the day by chastising and binding the sun, and who is credited with many impish tricks, all of which the Maori delights to recount. But no reverence of any kind is paid to him.

As to Hine-nui-te-Po and her origin, it was in this wise: Tane, one of the progeny of Rangi and Papa (Sky and Earth), sought his parent Rangi and asked, "Where is the female element?" Rangi replied, "The female element is below; the abode of life is above." This may refer to Papa, the Earth Mother, whose place in nature is below the heavens, while above is the vast expanse of the heavens, the denizens of which know not death. It is evident that for many centuries the Maori mind has been deeply imbued with animism, as a study of their myths will prove to the inquirer.

One authority gives the following as the reply of Rangi to Tane: "The female element is below: it is the abode [or origin] of misfortune, of death. The realm of life is above. Our descendants shall not be as we are, and as are our grandchildren—the sun, the moon, the stars, the Hinatore, Pari-kioko, and Hine-rauamoa—for they shall know death, the death of the lower world, and be mourned" ("*Kia mate ao, kia mihia, kia tangihia ai*").

Whether the term used in this myth—*i.e.*, "*uha*"—applies to the Earth Mother, or to Hine-nui-te-Po, who is said to have brought death to man by slaying Maui in a very singular manner, it is evident from a perusal of this myth that death and misfortune were supposed to have been caused by, or originated with, the female element.

Tane sought long for the female element, and in so doing he produced trees, shrubs, and plants, until he came to two beings named Roiho and Roake, who told him where to find woman. That woman was Kurawaka, who had been formed by Tiki by means of the *tira* rite. She was formed from the sacred mound termed Puke-nui-o-Papa, which represented the *po*, the realm of darkness, of oblivion, and sin. By Kurawaka Tane had Hine-ahu-one. He took his daughter to wife and had Hine-ahuarangi, whom he also married and had Hine-titama. Tane took her also to wife, until one day she asked, "Where is my father?" Tane replied, "I am your father." So shocked was Hine-titama to learn this fact that she fled to the lower world, to Tane-te-wai-ora. She was pursued by her father (whose full name was Tane-nui-a-rangi), but refused to return with him, saying, "Return thou to the upper world, that you may draw up our descendants to light and life; while I remain here below to drag them down to darkness and death."

Here some Natives state that Hine-titama became Goddess of Death and of Hades, and was ever after known as Hine-nui-te-Po. Others say that Hine-nui-te-Po was a daughter of Hine-titama and Tumurangi. Yet again other versions give Hine-ahu-one as the one who became Queen of Hades, others that Hine-a-tauira (which seems to be another name for Hine-ahua-rangi) obtained that important post. However that may be, it is admitted by all authorities in this district that Hine-nui-te-Po is Queen of Hades, and the origin or cause of death. Descendants of Te Tini-o-Awa state that she had two younger sisters, Mahuika and Hine-i-tapeka, who were the personification, or origin, of fire. Mahuika was the living fire, the ordinary fire of this world, while Hine-i-tapeka (or Hine-tapeka) represented the fire which burns in the underworld, the tokens of which are the charred trunks of trees, and charcoal seen in deposits of pumice, as at Kainga-roa. When Maui, the hero, sought to obtain fire for man he sought Mahuika for that purpose.

Hine-nui-te-Po.	Mahuika	Hine-tapeka
	(1) Tako-nui,	(1) Motumotu-o-rangi,
	(2) Tako-roa,	(2) Ngarahu-o-ahirangi.
	(3) Manawa,	
	(4) Mapere,	
	(5) Toiti.	

Now, the fire seems to have been contained in the body of Mahuika herself, or in her fingers. The names of her five children given above are those of the fingers and toes, beginning with *tako-nui*, the thumb, or big toe, down to *toiti*, the little finger or toe. These were the fire children, or offspring, of Mahuika, whose name is viewed as a synonym for fire. The names of Hine-tapeka's offspring imply firebrands and charcoal.

When Maui applied to Mahuika for fire she pulled off one of her fingers and gave it to him. This finger *was* fire. Maui took it aside and promptly extinguished it, after which he returned and demanded again the fire of Mahuika, which was granted him. This also he extinguished; and so on until he came the fifth time, when the enraged Mahuika plucked off her last finger and cast it at Maui. The fire raged fiercely and pursued Maui, who was almost consumed by the same, when he bethought himself of calling upon his ancestors to cause the heavy rains to fall, which soon extinguished the pursuing fire. The remnants of fire fled to the woods and took refuge in the *kaikomako* and some other trees, from which the Maori people procure fire by the *hika*, or generating process.

Then it was that Hine-nui-te-Po resolved to avenge the destruction of the progeny of her sister Mahuika. To prepare the way, and to render Maui susceptible to her designs, she had recourse to magic, for it had come to her knowledge that Maui had designs against her. She sent one Kahukura (a butterfly) as a messenger to obtain the *aria** of Maui, in the form of a drop of his blood. But Maui slew the messenger with a slap of his hand. Then Hine despatched Waeroa (the mosquito), but Maui heard the insect humming and destroyed it. Then Tuiau (the midge) was sent, and death was the lot of Tuiau. But when Hine sent the silent Namu (sandfly), success was won, and she obtained a drop of the blood of Maui, over which she performed certain rites of magic to enable her to take the life of Maui.

At a certain time the thought came to Maui that he would strive to gain eternal life for man, that man might revive from decay as the moon does. He called together his people—the forest elves, the birds, and the multitude of the Mahoihoi—and explained to them his design. They said, "Maui, you will perish. Beware! Your spirit has been taken by Hine-nui-te-Po." But Maui persisted, and so he and his people fared on until they found the dread Goddess of Hades, who was asleep. Said Maui to his folk, "You must be very careful not to laugh while I enter the body of Hine, lest she awaken and slay me. When I have gained [or obtained] her *manawa*, then all will be well. Do as I say and Hine [or her power to inflict death upon mankind] shall be destroyed." Then Maui essayed to enter the body of Hine by the passage whence man is born into the world. But when he had half entered, the strange sight was too much for Piwakawaka (the fantail, a bird), who laughed aloud. Hence awoke the dread Goddess of Death, who, by closing her *puapua* (? labia) caused the death of Maui. So perished Maui, the hero, he who performed marvellous deeds, but who succumbed in his effort to gain eternal life for man.

(*Ka ki atu a Maui ki ana iwi, "Kei kata koutou ki ahau. Mehemea ka uru ahau ki roto i nga puapua o Hine-nui-te-Po, kei kata koutou ki ahau. Ki te kata koutou, ka mate ahau; ki te kore e kata, ko ia ka mate i a au. Kia taea ra ano e ahau tona manawa, katahi ka hamumu ai koutou." Katahi ka tukua kia ngaro ki roto i nga kuwha o Hine-nui-te-Po, tu maro ana te nanakia i roto i nga kuha (kuwha) o Hine. Na, kua heke iho a Maui, ka tae iho ia ki nga puapua o Hine-nui-te-Po, e tuhera (tuwhera)*

* *Aria* = semblance. This blood would be used as an *ohonga*. (See Transactions, vol. xxxiv, p. 75.)

ana. Kihai i kata. No te tomokanga atu ki roto, katahi ka kataina mai e te moho-tupereru, katahi ka whakakopia mai nga nga kuwha o taua wahine, mate tonu iho a Maui. Ko Maui tenei ka mate i a Hine-nui-te-Po.)

In this version it is the *moho* bird which causes the disaster to Maui and the *genus homo.*

In an account of Maori magic given by an old Native of Ngati-Awa (tribe) I note the following passage: "*Me waiho ko te tawhito o Hine-nui-te-Po, ko tena te atua i patua ai te tangata nana i raweke a raua tamariki ko tona taina.*" The *tawhito* of Hine-nui-te-Po was the demon that destroyed the person who slew the children of her sister and self. This word "*tawhito*" is a very ancient sacerdotal term for the organs of generation in man (*membrum virile*).

The object of Maui in entering the body of Hine was to gain her *manawa*, a term which is applied to the heart, and also the breath (*manawa-ora*, the life-breath). In failing to effect this he lost the chance of acquiring eternal life for man, while Hine, in triumph, not only slew Maui, but carried out her will as to the introduction of universal death into this world. As her word was to Tane of old, ever she drags man down to the realm of death.

Some Native authorities state that it was Maui who argued with the Queen of Hades as to whether death should or should not be allowed to enter the world, and also that Maui had deeply offended her by interfering with her connection with Tuna, the eel-god. Maui decided, they say, to slay Hine on account of her practice of magic arts, by which means she destroyed many people. Her word was,—

Ka kukuti
Ka kukuti nga puapua
O Hine-nui-te-Po
Ka whai toremi.

The drop of Maui's blood obtained by Hine was used as an *ohonga*, or connection between her rites of magic and the person of Maui. (See vol. xxxiv of the Transactions, p. 75, for an explanation of this matter.)

The meaning of this singular allegorical myth may not be clear to our minds, for we have attained to a different plane of thought from that occupied by primitive man. We do not, and never will, understand the inwardness of the primitive mind. The time for us to do so has long passed away. But ever in Maori magic rites — barbaric ritual of a deeply superstitious people—may be noted the strange belief that the female genitary organs are allied to death and misfortune, while the male organ was resorted to in order to save man from disaster, from the charms and spells of magicians.

In an old invocation or incantation repeated by the priests of old in order to relocate the breath of life in an apparently dying person we find the following :—

Kai hea ?
Kai hea te pu o te mate ?
Kai runga, kai raro
Kai te hikahika nui no Hine-nui-te-Po, &c.

(" Where is the cause or origin of death ? It is above and below. It is in the organ of Hine-nui-te-Po.")

A singular discourse delivered by an old Native to myself puts a somewhat different complexion on the story of Tane seeking the female element. He said, " I will speak of life and death. When Tane approached his parent Rangi, in his search for the female sex, Rangi said to him, ' The *whare o aitua* [abode of misfortune or death] yawns below, while open above is the *whare o te ora* [site of life, &c.].' The former term implies the female organ, while the latter expression is applied to the ears, eyes, nostrils, and mouth. Now, when Tane found woman he was ignorant of the laws of procreation and of copulation, hence he mistook the purpose of the ears, nostrils, &c. Now, if Tane had not interfered with the *whare o te ora*, death would never have approached man; he would have retained life for ever, even as do the children of Tangotango, who are the sun, moon, and stars."

It will be noted that the above notes really contain two accounts of the origin of death, which may perhaps be accounted for when we know that these isles were not settled by one migration of Polynesians, but by at least two, whose myths and traditions may have differed somewhat. Moreover, I am becoming imbued with the idea that many such origins or myths bear a twofold aspect as recorded in Maori tradition, the one being of a sacerdotal character, retained by and known to but a few persons, such as the priests and chiefs ; while the other version is the popular one, known to all members of the tribe, and appears conserved in the folk-lore of the people, often interwoven with the doings of some popular old-time hero.

The adventures and deeds of such beings as Maui, Tawhaki, &c., are common property, told around any camp-fire, or in any place where Natives are gathered together. No reticence marks the imparting of such folk-lore tales to Europeans. But how different, and difficult, it is to acquire any matter pertaining to the real old-time religion, the cult of Io, the collector alone knows.

The underworld, or Hades, to which the spirits of the dead descend, is termed the " *po*," a word which also means " night." *Pouri* = dark ; *uri* denotes blackness or very dark colour

This underworld of the dead will be treated of later on, but I wish to state here that the "*po*" is a term often used as a synonym for death. In like manner the expression "*ao marama*" (light world, or world of light) is employed to denote life, the world of life, this world we live in. Hence "light" and "life" are, to the Maori, equal terms, as also are "darkness" and "death."

A natural death is termed "*mate aitu*," or "*mate tara whare*," sometimes "*hemo-o-aitu*." Suicide is known as "*whakamomori*."

In the very old myth of Mahu and Haereatautu mention is made of Noke, the Worm of Death. This Haere was one of the rainbow-gods of the Maori. He was taken by Mahu to a *paepae* (latrine), where Noke entered his body and caused his death. This myth, as obtained, is too fragmentary to carry any explanation with it.

How the Maori dies.

As a rule the Maori meets death calmly and without betraying fear, but not cheerfully. (Who does ?) He had no belief in any future state of happiness, in any realm of peace where the spirits of the dead abide amid either sensual, social, or intellectual pleasures; no spiritual happiness and contentment awaited him after death. His mentality had not evolved any form of belief in judgment of the soul after death, in any system of reward or punishment in the spirit-world for virtuous conduct or sins committed while in the flesh. Hence he had no fear of future punishment, of suffering in the next world for sins committed in the world of life. No priest terrorised imaginative minds with threats of awful sufferings after death, or demanded any form of payment for services rendered in averting such sufferings. To state, however, that the Maori possessed no system of ethology, as some writers have done, is quite wrong. His moral code differed considerably from our own, hence, with Western obtuseness, we cannot grasp it, or even recognise it. To discover and study that system you must examine the working of the laws of the *tapu* cult, the intricacies of which have never yet been fully explained by any writer. Sin to the Maori was invariably connected with some infringement of *tapu*. No man in olden times was allowed to take part in any sacred or important undertaking until his mind, or heart, had been purified by means of a very singular and sacred religious rite, which imparted to him moral, mental, and intellectual cleanliness. In the days that lie before we will endeavour to explain these matters.

The old-time Maori generally met death bravely on the battlefield, even when put to torture by enemies. When dying from disease or natural decay they do so calmly, and even in an apathetic manner. One does not notice in the Maori so situated any of the keen desire and struggle to live so often noticed among white people. His mind is too deeply imbued with fatalism for that. When stricken with illness, real or imaginary, the gloom of Te Po seems to already envelop him. More especially is this noticeable when a Native believes that he has been bewitched. Once let him get this idea fixed in his mind and his doom is sealed; he will surely die ere long. I have known such cases in this district during the past few years.

When a person fell ill he was almost invariably taken a little way from the village, and either a miserable shed of brush or palm-leaves erected over him, or he was simply left in the open. He would not be allowed to die in his house, on account of the intense *tapu* which pertained to death. If he did so, then the house could no longer be used, for it would be *tapu*, and would simply be left to decay. In former days, when fighting was of common occurrence, it often happened that a fortified village would be deserted on account of the blood of its occupants having been spilt there while defending the same against an enemy. In such a case, if no local priest was deemed sufficiently high in his profession to lift the *tapu* from the blood-stained defences, then the garrison deserted that place and built another fort elsewhere. When Te Kanapa and others were shot at the Mana-tepa Fort, at Ruatahuna, in the early forties, that stronghold was deserted by the garrison on account of blood having been shed therein. The forts known as Te Tawai and Te Kape, in the same valley, were deserted on account of certain people having been buried therein.

For the reasons above stated, the Maori usually died in the open air. When death was seen to be near, the sufferer was generally carried to the *marae*, or plaza, of the village, and there laid on some mats on the ground, either without covering (if fine weather) or with but a rude shed over him, which shed would probably be open at the sides. At the present time a tent is usually used for the purpose. But often they die absolutely in the open.

In many cases when nearing his end a person would say that he would die at a certain stated time, which he usually contrived to do. The people of his village, as also others, probably, from adjacent settlements, would gather at such time on the plaza before the dying man's couch and there await his dying words—*i.e.*, his advice, injunctions, behests, &c., as also his farewell greeting to his tribe. Such speeches are termed "*oha*," "*poroaki*," or "*poroporoaki*."

When old Whakamoe lay sick unto death by the shores of Waikare-moana, a Native Land Commission was expected to soon arrive at that place. The old man informed his people that he would not die until he had welcomed the Commissioners. Days ran into weeks, and the Europeans had not yet arrived. But Whakamoe clung to life, and kept his word; for one morning the waiting people saw canoes crowded with people leave the dark shadows under Huiarau and glide across the calm, bright waters of the rippling sea. When the visitors—European and Native—marched into the village plaza the world-weary old warrior was waiting for them. He lay on his last couch, on the ground, his relatives near him, and then was heard his voice uttering the old-time greetings of the Maori people as he welcomed the visitors from the outer world and the vale of Ruatahu-na. After this greeting he addressed his tribesmen, advising them as to how to conduct their affairs, and commending the visitors to their care and hospitality. And then he bade farewell to his people, and so fared forth upon the great unknown ocean, like the children of Pani of old.

A Native prefers to die in the open air: *He mihi ki te ao marama te take. Ka mihi ia ki te ao marama ka whakarerea e ia.* The reason is, he likes to greet the world of life and being. He greets the world he is about to leave. If a sick person asks to be taken out into the open, that is viewed as a sign of death being near. Sometimes, however, a person is not brought out thus into the open. The passing-away of a person, the last hour, is termed "*whakahemohemo.*" But even if a person died under shelter, yet the body would be exposed in the *marae* (plaza, court) after death for the mourning ceremonies, the lying-in-state—of which more anon. In the case of persons of low birth (*ware*), many rites and customs were omitted. He was a nobody, a person of no importance. But little ceremony pertained to the death of a *ware.*

Sometimes when a person of importance was nigh unto death a human sacrifice would be made. One of his relatives would slay a person as a "*koangaumu,*" as it is termed, the body being known as an "*ika koangaumu*" (sacrificial fish, or victim). The idea was an exaltation of the sick person. The body of the sacrifice was eaten, a portion of the flesh being given to the invalid. It is said that the act of slaying a person would serve the purpose of allaying the grief of the sick person's relatives, who expected soon to lose him.

The Maoris believe in omens innumerable. Signs of coming disaster, as a defeat in battle, or the death of a chief, are numberless. If a comet (known as "Tu-nui-a-te-ika") was seen, persons would ask, "Who is the striken one?"—for such was a sign of death. Some tribes or clans had tribal or family banshees, such as Hine-ruarangi, of the Ngati-Whare people.

These omens will not be inserted here, on account of their excessive number. Also, many of them have been published already in my paper on "Omens and Superstitions of the Maori." *

We will now attend the bedside of the dying Maori and see how he fares when caught in the "snare of Hine-nui-te-Po," as the saying has it. We will note his thoughts regarding death and the spirit-world; we will look with his eyes on strange rites, and stand by the priest who aids his soul to quit the wrecked body; we will follow him to the underworld and commune with the gods of Hades: and you shall see a man who dies calmly, and in times of stress—as under torture—bravely. For his mind has not been terrorised for long centuries by pictures of eternal suffering after death. His priests, in one respect, could teach us one grand lesson. He has not been taught to fear the hereafter.

The end is near. The sick person has been carried to the plaza of the village home or fort; his relatives and friends are gathered here to hear his last words. If he be an important person, practically the whole tribe are present—at least, all those dwelling near by—though I have seen Natives travel forty miles over rough bush trails to see their chief die and to hear his last words. If he had been taken ill away from home his relatives would carry him thence on a litter, so that he might die on his own land and among his own people—a very desirable thing among Natives. I have seen men so carried over the roughest forest ranges.

The dying man would be found lying on some mats placed on the ground, and covered with the scant clothing of primitive man, probably a cloak woven from the fibre of the so-called flax (*Phormium tenax*). When a Maori dies, such of his clothing as may have been used by him or have been in contact with him during his illness is either buried with him or burned at his death. In former times they possessed nothing in the way of clothing similar to European garments, but merely cloaks, capes, and kilts. Since the Natives have adopted European garments, relatives of a person near his end will often say to him, "Put on your clothes," and will assist him to do so. He thus dies in them, and is buried in them. If any such are left they are burned. But if he has any spare clothing packed away, such is not destroyed at his death, but is taken by relatives. Also, the vessels used to cook food in for a sick person, if his own property, are often destroyed at his death. They are destroyed for the same reason that his clothing was burned—lest others use them; for death has its

* See "Journal of the Polynesian Society," vol. vii.

tapu, as has birth. In entering and leaving the world man is under strong *tapu*.

But the tribe is waiting for the last words, the dying speech of our *tupapaku* (sick person). They have gathered to attend his death-bed—*i.e.*, to *whakahemohemo* him. Prior, however, to this last farewell the sick man has called his family around him—*i.e.*, the *gens*, or family group—and has expressed to them his wishes as to the disposal of his personal property, his interests in tribal lands, &c., so that no trouble may ensue in regard to the same after his death.

It must here be borne in mind that the Maori, being unacquainted with any graphic system, made all important arrangements such as the above by means of explaining them in a formal speech to his people or tribe or subtribe. The disposal of his property by a dying person in the above manner was equivalent to the making of his will. Such an arrangement would stand good, and be respected by the people, because it had been explained in the presence of the tribe or clan, as custom demanded. It was therefore a legal act.

"I speak of the days of old. When a man was near death, his people collected around him when they knew that he was about to leave them. The people assemble before him in the *marae* [plaza], they greet their passing chief: 'O sir, greetings to you! We wish you to speak to your tribe, to your family, to your offspring.' The patriarch speaks: 'When my face is lost to your sight, live peacefully with each other. Ever remember the persons who brought evil, and peace, into this world, as seen in Aotea-roa [New Zealand]. The evil came from Tu and Tangaroa, from Tane and Tawhirimatea; while peace and prosperity originated with Rongo and Haumia, with Ioio-whenua and Putehue. This [peace] is what you must hold to and preserve, as a means of salvation for the tribe in the time that lies before, as a treasure for the people, as a means towards peacefulness. Then shall the result be a treasured home, domestic peace, and a peaceful land. Troubles shall not assail you.' Before the people of Hawaiki came hither to Aotea-roa peace prevailed in this land, and the men of old strove to preserve such peace. Observe the words of Toi the Wood-eater, when he, a dying man, addressed his peoples. The tribes of Toi were assembled to say farewell to him, the lord of many clans. There were seen the Tururu-mauku, the Tini-o-te-Marangaranga, the Tini-o-Tuoi, the Rarauhe-maemae, the Kokomuka-tu-tara-whare, the Raupo-ngaueue, and many others. The Marangaranga greeted the old chief: 'O sir, greetings to you!' And Toi said, 'Be careful to preserve the peace and prosperity handed down to you by your ancestors. Respect the behests and trusts of your people who have gone before.' The Tuoi arose: 'O sir, the father of the people, the holder of the tribe, salutations to you!' And Toi replied, 'Hold to the welfare of your people, preserve it for the generations to come.' Arose the Raupo-ngaueue: 'O father, we greet you—you who nurtured the people that they might retain life in this world.' Said Toi, 'My words to you shall not differ. Your salvation—it is the advice given by Puhao-rangi and Ioio-whenua—the welfare of the tribe, preserve it.' So died the famed Wood-eater, Toi of Ka-pu-te-rangi."

It must not, however, be supposed that the last words of a Native chief were always of the above nature: far from it. The much-quoted Toi was the high chief of the *tangata whenua*, or original people, of the Bay of Plenty district, a people who were not, apparently, of a warlike disposition, in which respect they much differed from the later migration of Polynesians to these shores.

A leading feature in such valedictory addresses of a dying chief to his people lay in his strenuous urging of them to avenge such defeats, or murders, or insults as had been suffered by his tribe, and which accounts were not yet "squared."

The term "*oha*" is applied by the Maori to all wishes, instructions, and advice of a dying person, as also to the property he leaves to his descendants. It also applies to his widow and to the tribe (*Ko te hapu, he oha na te tangata rangatira kua mate*). Williams's Maori Dictionary gives: *oha* = to greet; *maioha* = to greet; *koha* = parting instructions, respect, regard, a present, gift, &c.; *oha* = a relic, keepsake, a dying speech; *whakatau-oha* = to make a dying speech; *oha* = generous, &c.

Dying people are sometimes farewelled by the assembled people before they expire, but most of such speeches are uttered when the body is lying in state—*i.e.*, after death. The *tangi* (wailing) also sometimes commences when the person is *in extremis*. The farewelling remarks of the people at this time, however, are as a rule not long speeches, but brief, sententious remarks, pregnant with mytho-poetic ideas and the mentality of a primitive people: *e.g.*, "*Haere ra, E Pa! Haere ki ou tipuna. Haere ki Hawaiki. Haere ra. E te pa-whakawairua! Haere ki Paerau.*" ("Farewell, O father! Go to your ancestors. Depart to Hawaiki. Farewell. O the *pa-whakawairua!* Go to Paerau.")

The terms "Hawaiki" and "Paerau" are in such cases used to imply the spirit-world, or perhaps the fatherland of the race in the sense of its being the place where the *genus homo* originated.

At other times the wailing commenced when the breath left the body.

The O Matenga and Wai-o-Tane-pi.

We will now glance at the singular custom of the *o matenga* (food for the death-journey), the supplying of food to a dying person for the long journey to the underworld, the realm of the dead. "*O*" is a term applied to food carried on a journey; "*matenga*" denotes the time or circumstance of dying. Apart from this "death (or dying) food," the spirits of the dead are often spoken of as partaking of food in the land of spirits.

"Just before death, or perhaps the day before, a dying person often asks for some article of food which he fancies he could relish. That food is obtained: it is eaten: then death ensues." The food so desired would be obtained for the sick person, however distant or difficult to procure.

Perhaps the favourite foods as *o matenga* desired by the men of olden times were — (1) human flesh; (2) earthworms (*toke*); (3) dog's flesh; (4) rats (*kiore*).

If when a person of rank was near death he desired to partake of human flesh as an *o matenga*, a party of his people would sally forth and slay a member of some other clan or subtribe of the surrounding people, or a member of another tribe. The body was cleaned, dismembered, and brought to the village home, where it was cooked in a steam-oven. A portion of the cooked flesh was partaken of by the dying person as his last meal in the world of life; the balance was eaten by the people.

When the war-party of Te Whakatohea Tribe, under Makawe and Heretaunga, attacked the people of Te Papuni, slaying Mahia and others, the chief Makawe was seriously wounded—so much so indeed that he was soon brought to his death-bed. When near his end Makawe called upon his people to provide him with an *o matenga* of human flesh. Thereupon a party of warriors attacked a village at Puke-taro, slaying several people. The heart of one of these victims was carried back to the Whakatohea camp at Te Huia. But Makawe had already passed beyond the need of *o matenga* in this world. Anyhow, that article would not be wasted.

Earthworms were another favourite *o matenga* in days of yore. The generic term for such is *toke* (or *noke*), but there are many different varieties, each having its distinct name. The two favourite kinds for the above purpose were the *whiti* and *kurekure*.* They were stoneboiled in vessels of wood or stone, and certain herbs (greens) mixed with them prior to being eaten. It is said that the sweet flavour (*tawara*) of this food remained on the palate for two days after the consumption

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* The *kurekure* is *Tokea esculenta*, named by Professor Benham. (See vol. xxxv of the Transactions, p. 64.)

thereof. So prized was this article of food that it was reserved for the chiefs. Hence it was termed a chief's death-food.

When Mura-kareke, a famous ancestor of the Tuhoe Tribe, came to his death-bed at Raorao-totara, a dog was killed, that its flesh might be utilised as an *o matenga* for him.

The flesh of the frugivorous native rat was also a much esteemed article of food, and often used for the above purpose.

Regarding the Native habit of changing personal names when any important event occurred, this often takes place when a person dies. In many cases such new name is taken from the *o matenga*, or last food partaken of by the invalid. The last thing so eaten by a person at Te Waimana was an orange, or "*arani*" in Native pronunciation. Hence a relative gave his newly born child the name of Te O-arani—*i.e.*, the orange *o matenga*, or the orange journey-food. Hatata, an old man of Rua-tahuna, recently assumed the name of Kuku because his grandchild ate some *kuku* (mussels) just before death.

A person at Rotorua partook of some *ti-ta-whiti* (a species of *Cordyline*) as a last food, therefore a relative assumed the name of Te O-ti. In another case, at Ruatoki, the final thing taken by the sufferer was a cup of tea ("*ti*" in Native pronunciation), hence a related child was given the name of Te O-ti. In some cases the last thing taken is a dose of medicine, or some stimulant. Hence the local names of Pua-wananga (= clematis; a medicine concocted from this was the last thing swallowed by a relative); Te O-parani (*parani* = brandy); and many others, too numerous to mention. These last three cases, however, should come under the heading of the *wai o Tane-pi.*

"A person is near death; he has ceased to partake of food, but can still take fluids. When he nears his end the sick one says, 'Give me some water.' That is the *wai o Tane-pi*, the last drink on his road to the realm of darkness." This expression, "the water of Tane-pi," is applied to the last drink taken by a dying person. It is a liquid *o matenga.* The term "*wai o Tane-pi*" is applicable to death. It was just cold water, the only beverage of the Maori in pre-European days.

When a man was near death he might say, "O that I might drink of the waters of [such a stream]!" and that water would be obtained for him, that he might drink thereof ere he passed away.

When Te Maitaranui (of Tuhoe) and Te Roro (of Ngati-Manawa) were slain at Te Reinga such an incident occurred. Te Roro fled, but was pursued and caught. Seeing that his end had come, he said to his captors, "*Taihoa ahau e patu, kia inu ahau i te wai o Kai-tarahae*" ("Do not slay me until I have drunk of the waters of Kai-tarahae"). Kai-tarahae is the name of a stream which flows into the river at the Reinga Falls. Te Maitaranui remarked, "*He manu hou ahau, he kohanga ka rerea*" ("I am but a fledgeling bird, a nest just forsaken"). This was in allusion to his youth, which did not, however, save him.

The origin of the name "*Tane-pi*" is not clear. Another form is *wai o Tane-here-pi*, which may be the same thing, or connected with it. When the Ngati-Tai people attacked the Panenehu at Wai-kurapa they slew the two children of Tu-namu—Tai-auhi-kura and Tu-auhi-kura. When their father heard of the death of the children he exclaimed, "Having fed you on the *wai o Tane-here-pi*, I thought you would have been strong enough to take care of yourselves."

The term "*whakamaui*" implies the rallying and recovery of a person apparently dying—"*Mana ano e whakamaui ake*" ("He may possibly rally round"). The origin of this expression is a feat performed by the old-time hero Maui. At one time during his adventurous career he was captured and slain, some say by Hine-nui-te-Po. But the slayers of Maui reckoned without their host, for the spirit of Maui entered into his body again, and he came back to life.

Manawa kiore: This expression implies the faint breathing of a dying person who is past speech.

Of a person *in extremis* a Native will say, "*Kai te ihu o te tupapaku te manawa e nga ana, kua kore kai raro,*" or "*Te manawa o te tupapaku kei te ihu tonu e kapo ana*"—meaning that the faint breathing is only noticeable by a slight fluttering or movement of the nostrils; the heart pulsates only at the nose.

The final expulsion of breath by a dying person is termed the "*puhanga ake o te manawa*" ("There is one final expulsion of breath, the eyes stare wildly, it is death").

Hirihiri; Ara Atua.

Of the many rites performed over a sick person by the *tohunga*, or priest, I shall not here speak, inasmuch as I have already put them into the form of a paper which was forwarded to the late Dr. Goldie, and which will appear in the forthcoming volume of the society's Transactions, together with many other items concerning Native treatment of disease, &c. There is, however, one rite, as performed by priests over dying persons, which has a place here, and that is the assisting of the soul or spirit of man to leave his dying body. This rite comes under the term of "*hirihiri*," which expression needs a few words of explanation, inasmuch as it has several bearings. The *hirihiri taua* is a ceremony performed over warriors about to lift the war trail, and has been described in a former paper. Another *hirihiri* is that peculiar rite by which a demon which causes disease by entering the body of man is forced by priestly arts to leave the sufferer's body and take itself off. The *hirihiri* of which we now speak is a rite the performance of which assists the soul of a dying person to quit his body and wend its way to the land of spirits. One of the objects of this ceremony is that the departing spirit may be induced to pass straight to spirit-land, and not remain in the vicinity of its former physical basis to afflict the living.

In the performance of this peculiar ceremony the priest suspended over the mouth of the dying subject a piece of the *harakeke* leaf (*Phormium tenax*), or a blade of some sedge-like grass, or of *tutumako*. This was the *ara atua*, described by me in Dr. Goldie's paper. By it the passing soul was supposed to leave the body, and was assisted to do so by means of an invocation recited by the attendant priest, and termed a "*hirihiri*."

So soon as the breath of life has left the sufferer's body the wailing for the dead is commenced by surrounding relatives. Since the introduction of firearms a custom has obtained of firing guns when a person dies, and also during the mourning ceremonies which follow. This is termed a "*maimai aroha*" (token of affection).

The eyes of the defunct are closed by a relative.

When the sound of gun-firing is heard at a place where it is known a person has been lying ill, then it is understood that he is no more. and people may be seen wending their way from adjacent settlements to that place, in order to join in the wailing (*tangihanga*) for the dead. Sometimes guns are fired just prior to death, when it is evident to the attendants that he is passing away.

In former times it often occurred that on a man's death his widow or widows would commit suicide—usually, perhaps, by hanging themselves, or by throwing themselves over a cliff; but in later times, often by means of firearms.

So soon as the death of a man occurred his body was "trussed" for burial—*i.e.*, before it became cold; albeit it would not be buried for some days. This "trussing" process, styled "*rukuruku*" and "*korukuruku*," consisted in crossing the arms on the breast and drawing the legs up until the knees rested on them, under the chin. A cloak was wrapped round the body, and the limbs retained in the above-described position by means of a cord lashed round the body. The bodies of women were also manipulated in this manner.

Mortuary Sacrifice.

No description of Maori eschatology would be in any way complete without some reference to the custom of human sacrifices pertaining to the death of members of the chieftain class. As old Tutakangahau put it to me, "A person was slain for a dead chief, as a *koangaumu* [see *ante*]. A person of another *hapu* [subtribe] would be killed for the purpose, and ever after the people of that *hapu* would be subjected to such remarks as, 'You were the human sacrifice for my ancestor.' This custom of sacrificing a person was an exalting of the dead person, a making much of him."

If it was believed that the dead chief had been bewitched, then the person who it was believed had bewitched him, and so caused his death, was selected as an *ika koangaumu*, or sacrifice, or perhaps another member of his tribe if the real culprit was not available.

There were two purposes for which persons were slain, in cases where no witchcraft was suspected. Men were killed to provide human flesh for the funeral feast, but these were often slaves of the tribe, and the butchering of them was not a ritual performance. But the *putu kai* was a very different thing. A person of good rank, perhaps a relative of the defunct chief, was slain as in exaltation of, and a token of respect to, the dead. In this case, however, the body of the sacrifice was not eaten. The sacrifice was sometimes selected from the same subtribe as that of the dead chief, but more often from a different one. He would not necessarily be slain at the home of the deceased chief, nor yet his body be brought there. But a party would go forth and slay him wherever they might find him, among his own people, and simply leave the body lying where death overtook it, for his friends to bury.

I have failed to obtain any confirmation of a statement made by some writers that these persons were sacrificed at such a time in order that their spirits might attend that of the deceased chief to or in Hades, and that men of rank were never slain for the purpose.

Mourning for the Dead.

When a Maori dies the body is laid out on or near the *marae* (plaza) of the village for several days before it is buried, and it is during this period that the mourning is carried on. The corpse is laid upon mats of woven or plaited fibres of New Zealand flax, or of *kiekie* (a climbing plant with leaves which contain a strong fibre), and is covered with a Native cloak woven from the fibre of *Phormium tenax*, or New Zealand flax. Possibly a rude shed may be erected in which to so place the body. In modern times a calico tent is often used. In this way is the corpse exposed to view prior to burial, and before it assemble the mourners, save the near relatives, who are grouped near and on either side of the body. In the case of a person of the chieftain class, the corpse is decorated in various ways, and his weapons are suspended near his body, or laid by the side thereof. It is, in fact, a lying in state.

To describe this lying in state a Native will say, "Such a person is lying on the *atamira*," or "The corpse is lying on the *atamira*." The Maori dictionaries give this word as meaning "a low stage on which a dead person is laid out, one end being elevated for the head." However, it is now merely a figurative expression, no stage being used, but only mats. In former times the bodies of members of the *rangatira* or chieftain class were covered with fine ornamented cloaks. The hair was dressed carefully, and prized plumes were placed therein. The garments, &c., actually lying on the body, or in which it was wrapped, were buried with it. Those cloaks or weapons hung near the corpse were not so buried.

At the present time a corpse is either laid out straight, or is propped up by and leans against a supporting structure.

If at death it was noticed, in former times, that one or more fingers of the dead person were extended, that was taken as a sign that a like number of his relatives would die ere long.

The mats on which a person lies at death are burned. If he dies in a hut it must be burned, or deserted as *tapu*. These precautions are taken in order to prevent the spirit of the dead from returning to trouble the living.

In addition to his weapons, fine garments, &c., exhibited on a person's bier as a sign of his chieftainship, it was also a custom of yore to so display any prized heirloom or treasure of the tribe with a similar view. But the defunct one must have been a person of importance in the tribe to allow of such a procedure, for many of such ancestral treasures were looked upon as being sacred. Any person so depositing a prized family heirloom on the bier for the period of the lying in state paid a great token of respect to the dead.

When a person was lying in death in former times, should he fancy that he had been bewitched, and so done to death, one would take a fernstalk in his hand and strike the body with it, saying at the same time, "*Anei to rakau; anei to rakau hai ranaki* [*rangaki*] *i to mate*" ("Here is your weapon; here is your weapon wherewith to avenge your death"). This act was to incite the *wairua* (spirit) of the dead person to turn upon the bewitchers and destroy them. (*E whakatara ana tena i te wairua o te tupapaku kia haututu, kia tahuri ki nga tangata nana i raweke.*)

In Major Heaphy's account of the Natives of Port Nicholson as noted in 1839 he speaks of the fight near Wai-kanae known as "Te Kuititanga." "We entered the *pa* [fort] about three hours after the fight was over. The chief, killed by a musket-ball, lay in state on a platform in the large enclosure [*marae*]. His hair was decorated with *huia* feathers, a fine *kaitaka* mat [cloak] was spread over him, a greenstone *mere* [battle-axe] was in his hand, with the thong around his wrist; his spear and musket were by his side. The bodies of slain persons of inferior rank were lying in the verandahs of their respective houses, each covered with the best mat [cloak], and with the personal weapons conspicuously placed beside," &c.*

As observed, so soon as the breath of life departed the wailing for the dead was (and is) commenced by those present. Silent grief is not thought much of by the Maori. When the people of neighbouring settlements hear the gun-firing, or lamentation, they repair to the scene. The relatives of the dead are nearest the body, the other portion of the assembled people are standing further from it, but at one or both sides, not in front of it, and facing the direction in which the mourning party will march on to the *marae*, or village courtyard or common. They are perfectly silent, save a few old women, who are in advance of the main body, and, with bowed bodies, are weeping and wailing in an extremely doleful manner. No cry of welcome is heard. The mourning party march up in column, very slowly, and utter no sound. When within a distance of 30 yards, more or less, of the village people, and facing them and the corpse, the column halts, and then the *tangihanga*, or crying for the dead, is commenced by both parties. No word is uttered, but the mournful crying and wailing has a most lugubrious sound. A Maori can open his tear-fonts at the shortest notice, even when attending the obsequies of his greatest enemy, for whom he has neither liking nor respect. They have a poor opinion of the silent grief of the white man, and express doubts as to its genuineness. A Maori *enjoys* a *tangi*, certainly if the defunct person is not a near relative or friend.

The mourners do not look at each other, or at the opposite party, during the crying, but usually look downwards. The tears simply stream down their faces; also their noses have an unpleasant habit of running copiously at such times. Hence the old-time saying, "*Ko Roimata, ko Hupe nga kai utu i nga patu a Aitua*" ("Tears and Hupe† are the avengers of the strokes of misfortune"—*i.e.*, of death). This expression is often made use of in funeral speeches. A Maori mourning party is not a pleasant sight.

This scene continues for some time. Those seen by myself were continued for varying periods, from half an hour to per-

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* See "Transactions of the New Zealand Institute," vol. xii, pp. 38–39.

† *Hupe*: Discharge from the nose is so termed.

haps two hours. But a similar scene would be enacted on the arrival of every fresh mourning party, which might arrive, at ever widening intervals, for a year after the death of a person.

During the *tangihanga* or weeping there are usually several elderly or old women who advance to the space between the two parties—*i.e.*, who place themselves in front of their respective parties—and there, with bowed bodies and outstretched, quivering arms, appear to act as chief mourners, though they may not be the nearest relatives of the deceased then present. This is termed "*tangi tikapa.*" These few persons occasionally wail forth a line of some dirge, and then recommence their wordless wailing sound.

Another custom much in evidence formerly at such times, but now discontinued, was the *haehae*, or laceration of the body by mourners.

"A Maori dies. The people collect for the wailing. The nearest relatives of the dead show their affection by lacerating their bodies, faces, arms, and legs until they are scored all over. It was a token of affection. Though the dead be male or female, daughter or son, that was the sign of affection of our ancestors. The greatest sign of their affection was the preserving of the head of a relative and carrying it about with them. But Christianity put a stop to that. The laceration of the body was done with obsidian [flakes]: hence these words in an ancient dirge, '*Homai he mata kia haehae au*' ['Give me obsidian, that I may lacerate myself']."

This custom of cutting the body was practised by near relatives of the dead only (among the Tuhoe Tribe). These mourners presented a gruesome sight, stripped to the waist, blood streaming from numerous gashes made by the keen obsidian (*mata*).

Anent this cutting of the body at funeral obsequies, Andrew Lang, in his "Making of Religion," looks upon it as being practised as a counter-irritant of grief, and a token of recklessness caused by sorrow. The Maori ever gives the one explanation thereof—*He tohu aroha*—a sign of affection or sympathy. As the word of old was "Ye shall not make any cuttings in your flesh for the dead," so has the custom died out in these isles.

Another custom among these Natives is that of presenting gifts to the bereaved clan or relatives of the deceased. Such gifts are termed "*taonga kopaki*" (*taonga* = goods, property; *kopaki*, as an adjective = wrapping, enveloping, covering). Some of the persons who join the visiting mourning parties will bear with them such articles as fine cloaks, polished greenstone ornaments, &c. After the *tangihanga*, or wailing, is over such persons will step forward and present their gifts, laying them on the ground in front of the assembled people of the place. This is a token of sympathy, of condolence.

"Friend, a further word. When a Native chief dies we do not merely lacerate ourselves, but also collect food to take to the obsequies for the dead; also fine garments, and jewels [greenstone ornaments]. Those who are mourning for the dead are stripped [to the waist]. They lacerate themselves. Their eyes glare wildly. When the lamentation is over the gifts are handed over—namely, the *taonga kopaki*. Then the greeting to the dead commences; he is farewelled. Also are greeted, and sympathized with, the living relatives of the dead."

It is also a custom for mourners to carry at such times green boughs of trees or shrubs in their hands, and to wear on their heads fillets or chaplets of green leaves, &c. I have heard it stated by Natives that in former times it was not the custom to invite people to come and mourn for the dead, as is often done now by the relatives. It was left for people to so come of their own initiative, prompted by their sympathy. The *kiri mate* (an expression applied to relatives of a deceased person) would announce their intention of so going, and others would accompany them.

"Our ancestors desired that man should die as the moon dies—that is, die and return again to this world. But Hine-nui-te-Po said, 'Not so. Let man die and be returned to Mother Earth, that he may be mourned and wept for.' Hence it is that we see the Maori people going to greet and weep for those who have died by the house-wall. And those also who have died by drowning or other accidents, there is but one way to avenge their deaths, and that is by lamentation. The only return is that of greeting, of weeping. The mourning parties go forth to wail for the dead, and thus is death avenged [equalised]."

When the visiting mourners are making speeches on the plaza, after the wailing is over, they speak directly to the dead, and not in the third person. They ever speak in eulogy of the deceased, of his good qualities, his generosity, hospitality, courage, &c., frequently crying him farewell, and using many peculiar expressions, figurative, mytho-poetical; quotations from ancient myths, proverbial sayings, and aphorisms. Extracts of an allegorical nature culled from old-time lore, dirges and laments for the dead, are all introduced into their speeches. The companions of the speaker will join in many of the songs, perhaps in all, but the village people will not join in rendering those of the visiting mourners, nor will the latter join in those of the village people. After the wailing is over and the speeches are commenced the people usually sit on the ground, only the speaker standing, except when a song is sung, when those who join in it all stand up, usually grouping themselves together, and always facing the opposite party.

The people of the place where the dead person is lying are the first to rise after the wailing is over and deliver speeches. The principal persons only of either side deliver such formal speeches. When the first speaker has finished another arises, and so on. When the last speaker of the home people has finished there is a short pause ere the first speaker of the visitors arises. This is to make sure that the home people have finished speaking.

The speakers of the home people will first address the visitors somewhat in this strain: "*Haere mai, haere mai, haere mai. Haere mai te iwi; haere mai nga rangatiratanga; haere mai nga mana; haere mai ki te mihi ki to tatou papa e takoto nei. Kua hinga to tatou rata whakamarumaru. Ko te manawa ora kua riro, ko te ahua anake i waiho. Ko tenei, haere mai; haria mai nga mate o era kainga, utaina mai ki runga ki nga mate o tenei kainga. Ko tatou he morehu no aitua,*" &c. ("Come hither, come hither, come hither. Come the people; come the rank, the prestige; come and greet our father who lies before us. Our sheltering tree has fallen. The breath of life has departed, the semblance alone is left. So now come hither, welcome; bear hither the troubles of other homes, join them to the afflictions of this place. We are but the survivors of misfortune.")

When a speaker of the visitors rises he will first address the home people: "Call to us. Call the troubles of other homes. Call to the people who sympathize with you. It was said of old that man shall be caught, one and all, in the snare of the Goddess of Hades, that he shall be mourned and wept for. Hence we come hither. By tears and grief alone shall [a natural] death be avenged," &c. Then, turning slightly, so as to immediately face the dead, the speaker addresses the body in the second person: "*Toku papa, haere. Haere, haere, haere, haere. Haere ki te Po—haere ki te Po—haere ki te Po. Haere ki ou tupuna. Haere ki Hawaiki. Haere ki ou matua. Haere ki Paerau. Haere ra, te maioro te karia, te whakaruru hau. Haere ki Tawhiti-nui, ki Tawhiti-roa, ki Tawhi-ti-pamamao. Taku toi kahurangi, haere. Marua ana te whenua i a koe kua riro i te tari a Hine-nui-te-Po. Kua kore he tangata hai arai i te kino, i te aha, i te aha, i te aha,*" &c. ("My father, farewell. Go, go, go, go. Go to the spirit-land—to the spirit-land—to the spirit-land. Go to your ancestors. Go to Hawaiki. Go to join your elders. Go to Paerau. Farewell, the breastwork of the people, the shelterer from piercing winds. Go to Tawhiti-nui," &c. "My protector, farewell. Defenceless is the land since you were caught in the toils of the Goddess of Death. Remains none to avert evil," &c.)

It will be observed how mourners farewell the dead to Hawaiki, to Paerau, &c. The latter seems to be a term applied to the spirit-world. But Hawaiki and the various Tawhiti are names of lands wherein the ancestors of the Maori sojourned in times long past away. Hawaiki, say the Native legends, is a far-distant land where originated the Maori race, hence the spirits of the dead are supposed to return to the primal home of the Maori, and are so farewelled by the living. Hawaiki lies to the west, towards the setting sun, and the departing place of spirits is situated on the western or north-western parts of not only New Zealand, but also the isles of Polynesia inhabited by the Maori race.

"A Native dies. The living bid farewell to him. The cry is, 'Go to Hawaiki.' That was the permanent home of our ancestors, hence this ancient cry of farewell to the dead. Although dead, and separated from the living, that is the address to them, to those whom death has taken." Here in this explanation, given by a Native, we see the Maori idea that spirits of the dead fare to Hawaiki, the cradle of the race, where man originated.

When a chief dies, the high mountains or ranges of his district are mentioned in such funeral speeches, for such natural objects, or some of them, possess considerable prestige. Such hills in this district of Tuhoeland are Maunga-pohatu, Te Peke, and Manawaru. "*Ko Maunga-pohatu te maunga, ko Pohokorua te tangata o raro*" ("Maunga-pohatu is the mountain, Pohokorua is the person beneath it") is a common style of expressing this idea.

"*Whare mate*" is an expression applied to mourning relatives of the dead. The near relatives of the deceased would not take food until after the burial, except at night, and in secret.

A peculiar term, "*makau*": This is given as = spouse, wife, or husband, in Williams's "Maori Dictionary," but Tuhoe do not seem to use it in that sense. Here it is applied usually by elderly women to their children or grandchildren, perhaps only in laments or addresses to the dead, as, *e.g.*, "*Te makau a te ipo—e,*" or "*Mai ra te makau—e.*" A great many endearing terms are applied to children in funeral speeches, as "my sweet-scented necklet," "my jewel," &c. In like manner are men compared with, and addressed as, "the white hawk," "the *totara* sapling."

Some time after the funeral ceremonies are over, perhaps a month after or longer, sometimes a full year, according to inclination and leisure from crop-work, the relatives of the deceased will form a party and proceed to visit other places and other subtribes or tribes as an *uhunga*, or mourning party.

Their object is to *kawe te mate* (convey the death) to other divisions of the tribe, to the more distant relatives of the deceased. When they arrive at a village the party will go through the same weeping and lamentation as already described. The speeches also are of a similar nature. Should any member of the people visited have died recently, then he will be included in the *tangihanga*, or mourning; in fact, such weeping, mourning, and speeches will apply to all persons of the two parties who have died since such parties last met to mourn for their dead.

One occasionally hears of very singular customs connected with mourning for the dead. I insert here descriptions of a few such.

After the defeat of the east coast Natives at Maketu, the following lament was composed as a *whakaoriori potaka* (song sung to the spinning of tops). The people would collect together, many of them being provided with humming-tops of the old Maori pattern. The people would sing the first verse and then all cry out the words "*Hai! Tukua!*" The last word was the signal to the top-spinners, who simultaneously started their tops spinning. The moaning or wailing hum of the tops represents the moaning sound made by mourners for the dead. When the tops are run down they are restrung, and another verse of the lament is sung, the top-spinners waiting for the cry "*Tukua!*" before starting their tops off again. I have seen a party of Natives going through this singular performance.

Kumea!
Toia te roroa o te tangata—e
Ina noa te poto ki te oma i Hunuhunu—e
Hai! Tukua!

(2.)

Nga morehu ma te kai e patu—e
Ko te paku kai ra mau, E Te Arawa—e
Hai! Tukua!

(3.)

E ki atu ana Karanama, e noho ki tamaiti nei—e
Takiri ana mai te upoko o te toa—e
Hai! Tukua!

(4.)

Koro Mokena, huri mai ki te *Kuini*—e
Koi rawerawe ana ou mea kanu kaka—e
Hai! Tukua!

(5.)

Na Tamehana ano tona whenua i utu
Ki te maramara taro—e
Waiho te raru ki to wahine—e
Hai! Tukua!

The following is equally as extraordinary as the foregoing. When several men of the Ngati-Tawhaki clan of Tuhoe were killed in the fight at Mana-te-pa, at Rua-tahuna, about 1840, one Tu-kai-rangi evolved the following scheme as a lament for the dead, and to banish the sadness and gloomy feelings of the survivors. This proceeding would be said to avenge, or equalise, the deaths of the friends of the performers. Tu-kai-rangi erected two *moari,* or swings (giant's strides), one near Mana-te-pa and one at Kiri-tahi. The following song was composed and sung while the swings were used. Grasping the ropes of the swing, the performers sang a verse of the song given below and then swung off round the pole, one after the other. When they stopped another verse was sung, and again the people whirled round the pole, and so on.

Tu-kai-rangi, hangaa he moari
Kia rere au i te taura whakawaho
Kai te pehi Hiri-whakamau
Na wai takahia.

(2.)

Taku aroha ki a Te Haraki—e
Nga whaiaipo a Te Hiri-whakamau
Na waitakahia.

(3.)

He taura ti—e
He taura harakeke
Nga taura o Te Hiri-whakamau
Na wai-takahia.

Another token of mourning in former times was the cutting of the hair. One way was to cut off all the hair very short with the exception of one patch, of perhaps 2 in. diameter, on the left side of the head. This was left the original length, of perhaps 2 ft. or less, and was allowed to hang down. It was called a "*reureu.*" I have seen a woman with her hair so cut when mourning for her dead child. This latter case, however, would probably not have occurred in former times, as Native women appear to have worn their hair short. Men, however, wore their hair long. A widow or widower would have all the hair cut off short. The hair cut off is buried with the corpse.

When a Maori dies, almost always a lament (*tangi*) is composed by relatives and sung during the period of mourning, usually when speeches are being made. Sometimes several are so composed for a single individual, if a person of consequence. Many old-time laments have been preserved for centuries, and are often extremely interesting, on account of containing allusions to the ancient history of the race. In fact, the laments and lullabies seem to be the most interesting of Native songs, and for a similar reason. Native laments of modern composition are, as a rule, very inferior, or, if they are not so, owe it to the fact that they are composed by wholesale cribbery from ancient songs.

The higher forms of dirges for the dead are termed "*apakura.*" They may be called laments of a sacerdotal character, and often contain ancient cryptic phraseology of an old-time cult. The ordinary lament (*tangi*) for the dead is of quite different composition—in fact, they resemble ordinary songs, and are often so used.

The term "*tangi taukuri*" seems to apply to a lament wherein the composer bewails his own evil fortune, or that of his tribe. The *tangi tikapa* and *tangi whakakurepe* are modes of mourning, lamenting the dead, while going through various motions, such as swaying the bent body from side to side, quivering the hands with arms extended. Sometimes a weapon (*patu* or *mere*) is held in the right hand while going through the above genuflexions.

I will now give two specimens of laments for the dead as illustration. The first was composed about eighteen generations ago, is a good specimen of ancient Maori composition, and contains many allusions to, and fragments of, old-time myths and history. My readers will regret to hear that it is incomplete, which accounts for its shortness. The second lament given is a modern one, composed about 1901 for a Native woman who died at Galatea.

He Tangi mo Rangi-uia, na Te Matorohanga. (A Lament for Rangiuia, composed by Te Matorohanga.)

E moe ana ahau i taku moe reka
Whakamatatutia
Ka maranga kai runga i te po roa—e, o
Hine-matikotai
I kukume tonu nei kia ngata te kanohi
Tena ra i a Tutapa-kahurangi
Puritia mai ra i te apai o te whare
Ka titiro iho koe, ka moe te kanohi
Ka tangi mai tona ihu, ka ngongoro tera
Ka waiho hai atua; ka tangi mai ki muri
Mauria atu ra e te au whakapeke a Tama-tukurangi
Ka paoa ki waho ra ki te Kopani—e,
Ki Te Kahu-o-te-rangi
Ko Te Ata-kaihia, ko Te Ata-hapara
Te ata ka pakaru, ka rere mai i te ra
Whiti ana i roto ra hai ohomauri hine
Ka tu mai te takahi ki a Tama-uru-rangi
Tomo atu, e hika! te tai o nui no rangi
I au e whiwhi—e, i au e nangara
Kauaka te rangi tapu taupurua iho
Ko te rangi tihore, ko te rangi waruhia
Kia marama koe ki te kete a Tane
I mauria mai nei hai tohu mo tona matua

Tataitia ra, tiwhaia i runga ra
Ki a Autahi, ki a Puanga raia
Ki a Takurua ra. Ringihia i te kete
Ko te Ika o te rangi ka ngako i runga nei
Ma Pua-hahana ra, ma Rauru, ma Wera
Tupatia iho ki te tihi o Tane
Ka mate i reira i a Tahu-kunia, i a Tahu-maero
Ko Tahu-aitu—e.
Ko koe ra tera, e hika !—e—i.

Whiti Tuarua (*Second Verse*).

Aue ! E hika ! Ki ou takanga nei
Ki nga marae ra
E kata haere ana ki te whatitoka nei
Hai atua kai ake mo roto i ahau
Aue !—i.
Ka tomo mai na koe te po tuauki
E ara ki runga ra, korero ki au
Kei noho puku koe te whare tahu
Ka maaha noa atu e roto i ahau
Akuanei, e hika ! Te wetewete ai
Kia puta ra koe i te rangi tuatahi
He uri au no Tane
I hangahanga noa ra i a Hine-ahu-one
Ka tu te ringa, ka tu te waewae
Ka tu te mahunga,
Ka toro mai tona ure ki runga ki te tipuaki
Koia te tota—e—i.
Ka tapotu ki roto te kanohi
Ko te karu tena
Ki te pongaihu, ko te kea tena
Ki te waha ra, ko te mare tena
Ki te keke ra, ko te riko werawera
Ka hangai ki te tara
Me ko Hine-manuhiri, nana te kahurangi
Ko Hine-kapua-rangi, nana te kohatu
Ko Hine-a-tauira, ko Uru-rata—na—i.
Ko ngangara tana ka waiho ki te rangi
Ko te Ao-tu—e, ko te Ao-hore ra
Te Ao-taru-aitu, te Ao-mata-kaka
Mo-uriuri—e, Mo-rekareka ra
Mo-hiku-tu—e, Mo-hiku-tohe ra
Mo-hiku-tauira,
Ko Whiro-te-tipua-manatu
Ko Tawakewake, ko Tawhangawhanga
Me ko Tama-ki-te-hau, ko Tama-ki-te-kapua
Te haerenga awatea ko Toi-te-huatahi
Ko ou tangata i te kai rakau
I te ponga, i te ti—e—i.
Ko Rauru tena ka tukua e koe
Ki Awa-tiko-kino
Kia mau, e hika ! Ki a Whatonga—e
Ki a Ruarangi—e
Ki a Pou-tiri-ao, ko Te Manu-tohi-kura
Ko Tane-hua-rangi, ka noho ko Rongomai-taha-nui
Ko Tama, ko Paikea
He tahuna akonga no te whenua

Ka whitia ki a Kahutia—e
Peka mai, e hika! Ki a Pouheni—e
Ki a Tara-whakatu
Ko Tara-a-punga, ko Tara-paea-ra
Ko Rakai-te-uru, matua papaki—e
Ko Te Rangi-tautahi, me ko Tamakimaki
Ka waiho mo te nuinga te pito i a koe
Ki te po—na—i.

Whiti Tuatoru (*Third Verse*).

Ko wai ra, e hika!
To mata i haere ai koe ki te Po?
Ko Turanga-wahine, ko Turanga-tane
Te mata tena o to tupuna
O Te Ao-ariki i te Manu-tukutuku
Ka hinga tona puta ko Wai-o-tira—e
I oma atu ra ki a Papa raia
I hurihia atu ra e Tane ki raro
Ka puta atu ki waho ko Ruaumoko—e
Tarewa i tona puta ko te Raukape ra
Ko Tama-reo-rangi ka kume i a tini
E waitohu ake ana ki te ao marama
Ka ngarue te whenua, ka ngaoko te moana
Ko te tumu o te rangi, ko te take o te rangi
Ko Maru-i-tauira, ko Maru-i-torohanga
Ko Maru-i-taura, ko Maru-i-tawai
Ko Maru-i-taketake, ko Maru-whakatupua
Ka ea ki runga ra, ko te Tumoremore
Ko te Tuhaha
Ko Rua-kapanga—e, te Manu-nui ra
Ko Rua-te-hohonu, ko U-wawe-ki-uta
Ko Manawa-pou—e
Ko Kourunga ra, ko Tu-mauri-rere
Me ko Rongo-whakaata, ko Rongomai-hikau
Ko Rua-whetuki—e
Ko Hitamu-rira, ko Turourou ra
Ko te Ika-whakatu ki roto o Turanga
E he mai na koe ki to hou matua
I tipu ai ki te ao, i wehi mai na koe
Kati ra, e hika! Hoki mai i kona
Pokaitia ra ki a Moetai—e
Kia rongo kau au ki a Kahukura-iti
Ki tenei tini ra, e taka i waho ra—e
Ko koutou tena, e tama ma e!

Whiti Tuawha (*Fourth Verse*).

Moe mori, e hika!
I roto i te whare kino, i te whare pouri
He uea ake ra ka he to manawa
Ka titiro ki waho ra
Ki te waka hoehoe ki Wai-roro ra—e
Ka puta te parakipa kai to ihu
Mau i moe po, no muri i mate ai
I tukua mai nei ko te tonga hawai
Ko te tonga taupuru
Ka pupuru te atua ki roto ki a koe
Ka whaia atu na koe
I a te Ao-matangi, i a Katakata—e

I a Wheruru—e, i a Kiwa raia
Nana nei te moana, nana nei ngaru nui
Nana nei ngaru roa
Ka wawae i te peka kia maranga ia
Kia tiko whare ra
Ki a Honuhonu—e, ki a Kekerepo
Ka taka mai ki muri
Hai autu tangi, hai autu pawa ra
Ka mamao ki te rangi, taku rangi pea
Ka tau ki raro ra ki Waianiu ra
Hai to matua—e, hai a Te Hau-ori—e
Hai a Ngapata ra
Ma te Hiakai koe, ma Hine-te-ariki
Ko Pikihoro pea, ko Hine-uru anc
Ko Tama-uia—e
Koutou ra tena, e koro ma !—e—i.

Below will be found a modern lament for the dead, although, as now is usual, it is modelled upon ancient forms—or, rather, it was composed by wholesale "cribbing" from old-time songs. The Maori poet of to-day seems to depend to a very great extent upon plagiarism, and seems to have lost the art of composing such fine pieces as the above. Observe, in the above, the pathos of the opening lines of the second verse, where the composer mourns the loss of his daughter: "Alas, O maid, for your playings in the village—running laughing to the door! These memories remain to consume me."

A Lament for Pare, of Ngati-Manawa.

He ao mauru e rere pokai ra
He mihi ra naku ki toku nei taina
Kua wehe i nga iwi
Kua wehe i taku tinana
Kua wehe i nga tau
Kua wehe i nga nohoanga.
Ka tahuri mai, E Pare !
Kei te mihi atu koe,
Ka tu ai te aroha
Taraia i te tangi ki a Mariri
Ka noho taua nga paeroa kai Rangitahi
Kia whakarongo koe nga tai o Whirinaki
E ngunguru nei
Ehara koe i te wahine,
He kuru tongarerewa
He uri koe no Rangitihi,
He uri koe no Tangi-haruru,
He uri koe no Apa,
He uri koe no Tuhoe-potiki
Tenei, e hoa ! Te mamae
Kai te tau o taku ate
Ki a taua kura
Kua mahue i a koe—i."

The Whare Potae (The House of Mourning).

The names "*whare potae*" and "*whare taua*" both mean "house of mourning," or "mourning-house" (*whare*, house;

taua, mourning). The word "*potae*" means, as a noun, a hat, or any covering for the head; as a verb, "to put over or on the head."

The term "*whare potae*," which is the form used by the Tuhoe Tribe, is derived from the *potae taua*, or mourning-cap (perhaps more correctly a fillet or chaplet, inasmuch as it possessed no crown). This was an article of mourning attire, a token of mourning for the dead. It was worn in former times by a near relative of the deceased, as a widow, during the period of mourning. It is composed of a band or fillet woven from some fibre usually, and which is put round the head and tied at the back. It has no crown whatever. Attached to this band would be a quantity of black, dried seaweed, or the epidermis of a water plant or rush known as "*kutakuta*," prepared as for a *maro kuta*,* and dyed black and brown, or left its natural colour of white and pale-yellow. These were attached by one end to the band and hung down, thus concealing the face and head of the wearer. Sometimes the tail-feathers (with skin attached) of the native pigeon, and those of the *koko* bird, were used to attach to the band. They swayed about when the wearer walked, or when affected by the wind. Chaplets of leaves of the *parapara* tree (syn., *puahou* and *houhou—Panax arboreum*) were also sometimes worn by relatives of the dead while in the *whare potae*—that is to say, during the period of mourning. The *potae taua*, with a crown, and no pendant strips, fibre, weed, or feathers, as figured on page 329 of Hamilton's "Maori Art," is an unknown article to the Tuhoe peoples.

The expression "house of mourning" must not be taken too literally, like unto many other expressions of the Maori. Albeit a Native will ever say, speaking of relatives of a person recently dead, "They are within the *whare potae*," yet he means that they are mourning for the dead. Although such mourners may be travelling, they are still spoken of as being within the *whare potae*. The term must be taken as implying the state or period of mourning.

Widows mourned their husbands for perhaps a year before marrying again. (*Ka tae pea ki te tau e whare taua ana te pouaru.*)

Bereaved persons, as a husband who has lost his wife, sometimes travel about for some time in order to forget their troubles. Thus a man may go and dwell among distant tribes for a year, or several years.

While mourners are within the *whare potae*—*i.e.*, during the period of mourning, which may continue perhaps for a week or longer—these dwellers within the house of mourning are very

* Trans. N.Z. Inst., vol. xxxi, p. 647.

careful in regard to taking food. As a rule they do not partake of food in the daytime, but only at night, and even then they eat in secret by going into some secluded hut by themselves, or at least where they cannot be seen by the people. Always they take their food under shelter, never in the open. If when travelling while an inmate of the house of mourning a person be overcome by hunger, and so compelled to eat in the daytime, he will go a space aside, break a branch off a tree, and stick the butt thereof in the ground. He will then sit under the branch while eating his food, thus likening the shade cast by the branch to the shades of night.

" *Tenei karanga, te whare potae, ehara i te tino whare, he kupu whakarite. Ko nga tangata kai roto i te whare potae, kaore e kai ao, engari kia po rawa, katahi ratau ka kai. He kai ao, ara he kai awatea, hai heuenga mo te whare potae. Ka haere te tangata ki te wai, horoi atu ai i te aroha; na, kua kai ao.*" ("This name, '*whare potae*,' it is not a real house, it is a figurative expression. Persons in the *whare potae* do not eat in the daytime, but only when quite dark; then they eat. Eating in the daytime—that is, in daylight—means the dispersing of the mourners. A person will go to the waterside and, by means of a certain rite, wash away his grief. Then he will eat in the daytime.")

It was not until the *tapu* had been taken off these mourners by means of a rite performed by the priest that they became *noa*, or free from *tapu*, and could take food in the daytime, or mix freely with the people. Cases are quoted where persons have so mourned for months. While persons are mourning they do not remain in a house, but move about, although not free from restraint, as the *tapu* is upon them.

There is a place in the Okahu Valley, at Te Whaiti, named Nga Wahine-kai-awatea (the daylight-eating women), which name originated in this manner: When Te Wharau, of the Ngati-Whare Tribe, died, his widow (and other female relatives apparently) was cleansed from the *tapu* of the *whare potae* at that place by laving her body with the waters of the stream and having the *whakanoa* rite performed over her. Then she (and her companions) first ate food in the daytime since the death of Te Wharau. Hence the above name. Observe how place-names change in Maoriland. When the road was being constructed to Rua-tahuna in 1896,

Te Wharau = Kete-kura (*f*)
Te Hahae = Hine-oho (*f*)
Tuahiwi = Hine-taro (*f*)
Whiri (*m*)
Kanarahi (*f*)
Te Meihana (*m*)
Te Horowai (*m*)
Pera (*m*).

the precipitous rock cliffs at Nga Wahine-kai-awatea proved a difficult place for the roadmen to work at—so much so, indeed, that it was found necessary to use life-lines (ropes secured at the top of the cliff and allowed to trail down the rock-face) for the security of the workmen. At once the Natives renamed the place Taura-tukutuku (the trailing ropes), and the original name seems to have been discarded.

A *koangaumu*, or human sacrifice, was sometimes made in olden times in order to take the *tapu* off the *whare potae* (*i.e.*, off the mourning) and its inmates the mourners. The act of so sacrificing a person would not break up the *tapu*, but such a sacrifice was always with the idea of imparting force, prestige, effectiveness to a religious function.

When Taupoki died at Te Whaiti a slave named Tapuku was slain as a *koangaumu* for the mourners. The body was cut up, a portion thereof sent to the Whirinaki people as a present, and the rest was cooked at Wai-kotikoti, just where the policeman's cottage now stands.

"*Ka mate te tupapaku, ka patua he tangata hai koangaumu mo taua tupapaku, ka kainga e nga whanaunga o te tupapaku. Ko taua patunga tapu hai heuenga mo te whare potae. Kaore e tangi te tangata i a ia e noho ana i roto i te whare taua. Kia koangaumutia te tupapaku ; katahi ia ka puta ki waho, ka tangi. Ko te koangaumu hai whakanoa.*" ("When a person dies, a man is slain as a *koangaumu* for the deceased, and is eaten by the relatives of the dead. That sacrifice is for the purpose of dispersing the mourners. A person does not wail for the dead while he is staying within the house of mourning. When the sacrifice has been made, then he will come forth and lament. The sacrifice lifts the *tapu*.") Here is an allusion to the fact that practically no crying or wailing for the dead is indulged in by mourners while in seclusion, but only when they are surrounded by others, and have an audience. The Maori believes in public grief, he cares not to weep in private.

The person slain as a human sacrifice for the lifting of the *tapu* from the *whare potae* would be taken from another *hapu* or subtribe. After this rite was over the mourners emerged from the house of mourning and returned to their usual avocations. Although usually merely a metaphorical or figurative expression, yet it would appear that sometimes a mourner nearly related to the dead would remain within the "house of mourning" (by staying in his own hut) during the period of mourning. In the legend of Pou-rangahua it is stated that Kanioro his wife so mourned for Pou when he was thought to be dead, and on his return he found her still secluded within their house, which had become overgrown with *mawhai*.

Sometimes a brother or sister of the dead would so seclude himself or herself for a time. Then it would be said, "Such a person is in the *whare potae*." "This action," said a cynical old Native to me, "was *hai whakananaha i tona ingoa*" (to get himself talked about). He said also that people often did such things for the brief fame that it brought them.

The ritual act of lifting the *tapu* from mourners is similar to that performed over any person who is *tapu* from any other cause. The person or persons accompany the priest to a stream, pond, or spring set aside for such sacred rites, where they divest themselves of their clothing, and, clad in nought save a scanty girdle of green-leaved twigs, they are sprinkled with water by the officiating priest, who then repeats over them a *karakia whakanoa*, or invocation to free from *tapu*. One authority states that the mourners had their hair cut at this function, which is probable, as haircutting was often performed as a sacerdotal rite.

The *apakura*, or dirge, sung by mourners is usually an ancient composition. It derives its name from a famous ancestor, one Apakura, a woman, who dwelt in the isles of Polynesia in about the ninth century of the present era.* She is looked upon by the Maoris of New Zealand as a kind of "parent," or teacher, of the art of mourning for the dead.

Pakipaki Mahunga.

The custom of the preserving of heads (*pakipaki mahunga*) of the dead by their living relatives has been alluded to. This was done out of a feeling of affection for the dead. The head was severed from the body, the latter being buried, while the former was dried and kept by relatives for some time before being deposited with the bones of the body in the cave or tree used for the purpose.

Pio, of Awa, speaks—he who has been caught in the snare of Hine-nui-te-Po, and has lifted the dread curtain which conceals the realm of Miru: "The great token of affection in old times was to cut off the head of a dead relative and preserve it, which was done by the priest. The head was shaken in order to cause the brains to drop out; the body was buried in the ground. The priest would carry the head about with him, sometimes exposing it to the view of living relatives, that they might greet and wail over it. This might continue for months, or even years. When unable to carry it about any longer, on account of other matters, the head would be taken to the burial-cave and left there. It was Christianity that put a stop to this custom. While

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* "Journal of the Polynesian Society," vol. viii, p. 15.

the head was kept, it was sometimes placed on a wooden peg (*turuturu*) stuck in the ground, and people would mourn over it. Near relatives would spread on the ground before it a *kakahu waero* (cloak covered with dogs' tails), upon which they would kneel before the head and chaunt an old-time dirge of the Maori people."

These dried heads were also exhibited at any important function or meeting of the people. They were stuck on stakes on the plaza, where meetings took place. Some had the lips stitched together, which, if neatly done, would elicit the remark, "*Me te kuku ka kopi*" ("Like the neat closing of a mussel-shell"). Some were left with the lips not fastened, hence the lips contracted during the drying or curing process, and the teeth became prominent. If the teeth were white and sightly it was remarked, "*Me te niho kokota*" ("Like *kokota* teeth"). "*Kokota*" is the name of a shellfish.

Heads of enemies were also preserved in a similar manner, but for a different purpose. They would so preserve the head of an enemy of the chieftain class that they might revile it, and subject it to all indignities the fertile brain of the Maori might conceive. Such heads would be placed in cooking-sheds and near ovens, a fearful thing to the Maori. They would be exposed to view on the plaza of the village, and reviled by passers-by. Women would place them near where they worked at weaving, &c., and occasionally turn to and curse them with great gusto, heaping opprobrious epithets upon them, jeering and taunting them, as though in the flesh. This would be when such women had lost husbands or other relatives at the hands of the dead or of his tribe.

The method of embalming or preserving human heads was a singular one. A steam-oven, similar to the ovens for cooking food,* was made in the ground. This was covered over save a small orifice left on the top and through which the hot steam escaped. Over this the head was placed, the base thereof being over the hole in the top of the oven (*umu*). The hot steam caused the brains to melt, when they were easily got rid of. The eyes were taken out, and the eyelids fastened down. The skin was stripped off down to the shoulders to allow for contraction; it was then brought under the neck and there tied. The Maori was very particular in preserving the heads of his relatives to render them sightly when exposed to people for crying over. He liked to see the lips closed so that the teeth were not exposed. He was not so particular with the heads of his enemies.

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* See Trans. N.Z. Inst., vol. xxxv, p. 88.

The expression "*pakipaki mahunga*" means "to preserve heads by drying." They were dried after the steaming process by means of placing them in the smoke of a wood-fire. The hair was retained, and was dressed and decorated with plumes when brought out to be wept over.

A description of this head-drying, with many notes, may be found at page 610 of the "Transactions of the New Zealand Institute," vol. xxvii, though the statement there made that in preserving the head of an enemy "no dishonour whatever was intended to the owner of the head" must be taken *cum grano salis*, for that is exactly what was intended. The quotation given from Marsden—"It is gratifying to the vanquished to know that the heads of their chiefs are preserved by the enemy"—is also very extraordinary, and absolutely incorrect. In the same article (p. 611) is seen the statement that "those [heads] of the enemy were usually placed on the tops of the houses, or on poles by the wayside, where they were exposed to the contemptuous taunts of the passers-by." This is certainly more correct, though how it could be "gratifying to the vanquished" is a somewhat obscure point.

The last case of head-preserving known to myself as having occurred in this district was in 1865, when Ngati-Manawa and some of Te Arawa were defeated at Te Tapiri, driven out of their fort at that place and forced to fly, leaving their dead behind them. The heads of two of these, Eru and Enoka, of Ngati-Manawa, were cut off and preserved, Kereopa swallowing the eyes. These heads were taken by Te Whakatohea to their home on the coast.

When, on a war-expedition in an enemy's country, the invaders lost some killed, the bodies were usually cremated, so that they should not be eaten by enemies. Sometimes the head would be cut off, preserved, and carried back home. When Ngapuhi returned from their famous raid to the Wellington District they brought back many heads of those who had fallen.

When Makawe, of Te Whakatohea, was slain at Te Papuni (see *ante*) his head was thus preserved by his people and carried with them on their raid to the Wairoa, where they fought at Tara-mahiti, after which they returned home to O-potiki, still bearing the head of their chief.

When Te Ika-poto's daughter died at Heipipi her body was buried there, but her head was preserved and taken to Maungapohatu, her permanent home.

The preserved heads of many former chiefs of the Tuhoe Tribe are lying in a cave at Te Tahora, among them being those of Te Arohana and of Te Mai-taranui.

Mortuary Memorials.

Memorial structures were not an important feature in Maoriland. Burial-mounds were never constructed, nor were graves marked by stones or posts. Two reasons may be given for this omission. In the first place, no burial in the earth was in any way permanent, save in such cases as when a body was buried in a swamp—trampled down into the mud and so left—or in a sandhill. Bodies buried in the ground were merely left there for a few years, when the bones were exhumed and placed in a tribal burial cave or tree. This custom has certainly obtained among the Maori people for centuries—*i.e.*, for so long as intertribal warfare has been general. It is possible that there was a period when the dead of the New Zealand Natives were buried in the ground and never exhumed, judging from certain discoveries made of skeletons in various parts. However, this may never have been a general custom. If it was so, then such dead were probably those of the original people of these isles, who seem to have been much less warlike than the later comers of the fourteenth century. The second reason to account for the absence of mortuary structures is this : On account of the savagely vindictive nature of Maori warfare, their eating the bodies of their enemies, and the delight they took in treating such bodies with every foul indignity, as also the custom of utilising the skull and other bones of such bodies wherefrom to manufacture various implements, it was necessary for every tribe to bury their dead in secrecy, and to take every precaution that enemies should not discover the resting-place of the bodies or bones of their dead. Hence nothing was done to mark a grave where a person had been buried. Perhaps the only marked resting-places of the dead to be seen about a settlement in former times were those constructed within the *pa*, or fortified village.

In regard to cannibalism, and the fierce lust for revenge which so often animated the Native mind, a dreadful illustration is that of the *kai pirau*—namely, the ghoulish custom which formerly obtained of exhuming the body of a buried enemy, cooking and devouring the same, even though decomposition had set in.

Little wonder that the Maori erected no gravestones. But they often so marked the spot where a man died, or fell in battle, as also a place where a sick man had lain. There were two methods of marking the place where a person had died or been slain. One was to set up a wooden post or place a stone on the spot ; the other was to dig a hole (termed "*pokapoka*"). Such a post would probably be smeared with red ochre, red being a favoured and also practically a sacred colour among the Natives. The *pokapoka* method was often employed whereby to mark places where men had fallen on a battlefield. Relatives of the dead person would make the pit or hole. Te Pokapoka o Taua-ahi-kawai is a place-name at Tara-pounamu. It is where the *pokapoka* for one Taua-ahi-kawai, of Ngati-Pukeko, was dug. But, observe, Te Pokapoka a Te Umu-tiri-rau, near Karioi, is a very different thing, for it is simply a hole dug as a landmark by Te Umu—hence the active "a." It is well to be cautious when dealing with the Maori tongue.

The *pokapoka* for the dead are respected by all members of the tribe. Some tribes term these pits "*whakaumu.*" The battle-ground of Puke-kai-kaahu, at Rere-whakaitu, had numerous pits on it to mark places where the dead fell during that Homeric combat.

A saying of old, "*E kore e pai kia tuwhera te pokapoka ki tahaki, engari me tuwhera tonu ki te papa o te huarahi,*" was often heard formerly when the war-trumpets boomed forth their doleful sound. It would be made by warriors in the course of their speeches before going to battle. Its meaning is, "It is not well that the *pokapoka* should be made in a non-conspicuous place, but let it be dug on a path"; by which the speaker implies that if he fall in the fray he wishes the sign to be made in a conspicuous place. The pit for a plebeian would be dug anywhere. These holes were about 1 ft. deep by 2 ft. in diameter.

I will now illustrate another custom of old. When a Maori is taken ill away from his permanent home and ancestral lands, should it be thought that his end is near he will be borne on a litter (*amo*) back to his home, in order that he may die among his own people and on his own land. In the rugged wilds of Tuhoeland I have known most arduous journeys of this nature made by Natives bearing upon their shoulders a litter or stretcher on which lay a dying person. Over rough country, up and down steep rough ranges, by narrow forest-tracks, and following up or down the beds of swift rivers, the bearers plod on for days, until their destination be reached. Te Puehu, of Tuhoe, lay sick unto death at Te Umu-roa. Then the thought came that he should be carried to Matatua, there to take leave of his people and lift the trail of death. So the bearers of the old chief bore their burden down the terrace lands above the rushing waters of Wai-hui, until they came to the steep descent to the Ruatahuna Creek. Here they rested awhile, setting down their burden by the wayside. In like manner when they had ascended the opposite side of the gully they again set down the litter by the wayside, near Te Whakatakanga-o-Te-Piki, and again rested. At both these resting-places where a person with the *tapu* of death upon him had lain a carved post or small pillar was set up to mark the spot, which remains *tapu.* Not only did these posts mark *tapu* spots, but they also served the purpose of a *tuapa*, and as a warning to passers-by not to trespass on the place. The post at the second resting-place was destroyed (burned) by the Native Contingent during Whitmore's raid on Tuhoeland, but the first one still stands, as I myself have seen. It is known as "Te Pou o Te Puehu" (the pillar of Te Puehu). These carved posts were usually sheltered by having a roof built over them, which would occasionally be renewed. The posts would also be smeared with red ochre. This Pou o Te Puehu was, for years after its erection, adorned by the Natives, who hung thereon any bright-coloured articles obtained from the coast tribes by barter, such as handkerchiefs, pieces of figured prints, &c. In like manner any tree where the severed umbilical cords of infants were deposited in former times was similarly adorned. This sort of thing would, presumably, be described as a fetish by travellers, and possibly as an evidence of tree-worship.

In regard to the *tuapa*: This name is applied to a post or slab of wood which had been hewn out of a log with an adze and was erected at the place where a person of rank had died, or in some cases where or near where he was buried. In some cases it seems to have been set up at or near the village where the person died. It would be erected after the burial. This slab seems to have in some way represented the *wairua* (spirit) of the deceased. The object was to lay the ghost of the dead person, to prevent his spirit from returning to afflict the living. Such a spirit of the dead is termed a "*kehua*," or "*kikokiko*," or "*whakahaehae*." Among the Tuhoe Tribe the first and last of these terms is applied to a ghost (spirit of the dead) as a ghost, but *kikokiko* is applied to those spirits of the dead that afflict the living, and are said to often cause death.

Certain rites were performed by a priest over these *tuapa** in order to prevent the spirits' return to afflict people, or crops, or other food products. The priest recites an incantation with this object. He then repeats the *karakia* (spell, charm, invocation, incantation) termed "*ahi*," at the same time rubbing a stick upon the ground as if generating fire, but he really kindles no fire. Thus are the evil designs of the *wairua*, or spirit, abolished or rendered innocuous. To give force, power,

* The general meaning of this word is, "something that obstructs, wards off, prevents contact with." It is also used as a verb.

to his incantation the priest then, by means of other old-time ritual, raises the tribal *hau*, or wind, that of the Tama-kai-moana clan being *tutakangahau*, and that of Te Ure-wera clan *uru-karaerae*. In some cases he will cause thunder to roll by reciting the *oho rangi* invocation. Having thus shown his power over the elements, he and the local *ruahine*, or wise woman, take the *tapu* off himself, and the function is over.

In some cases a stone might be placed to mark a grave—*i.e.*, an unworked stone, a boulder. It would be placed above the head of the body. These would probably be cases where the bodies were buried within or near a village, or in some remote spot where it was not likely to be found by enemies. For the Maori of yore was essentially a necrophagous animal, a ghoul of the first water.

Burial.

The Maori terms for burial are "*tapuketanga*" and "*ne-hunga*," derived from the verbs *tapuke* and *nehu* = to bury. Exhumation he styles "*hahunga*," from *hahu* = to disinter. Cremation he has no distinctive term for, but simply states that certain persons were "burned with fire."

We have already seen the mythical origin of the burial of the dead, when the Earth Mother said, "Leave me the dead. Let them return within me. I brought them forth to the light of day, let them return to me [when dead]. Mine shall be the care of the dead." Hence man is buried in the ground; he returns to the bosom of the ancient Earth Mother.

A single word: Ever bear in mind that the elaborate ceremonies and sacred rites described in this paper applied to persons of good birth only, not to people of low social status or to slaves. But little ceremony was wasted on common people, and as for slaves, their bodies would be thrown anywhere out of the way.

The general scheme of burial among the Maori people was—first the burial, or other disposal of the body, until the flesh had disappeared; and secondly the disposal of the bones of the dead in a permanent manner.

Among the Tuhoe Tribe the mode usually adopted was either to bury the body or place it on a covered stage or in a hollow tree until the flesh had disappeared, when, with great ceremony, the bones were for ever disposed of by placing them in certain burial-caves or in hollow trees, or concealed among parasitic plants on tree-tops. In the case of swamp and sandhill burial only was the body and its bones left in its first burial-place—in the first place on account of the difficulty of disinterring the bones, and also for the reason that they were safe from tribal enemies, seek they ever so closely.

Understand that Maoris think much of their dead, as becomes a people who have practised necrolatry for untold centuries. In like manner they think much of the places where their dead lie. Observe the evidence given in Native Land Courts, where two important points in support of a claim to land are that the claimant's ancestors died or were buried on the land. Note the pathetic laments composed and sung by tribes who were forced to migrate from lands where their dead lay. Think of the numberless cases where a captive has asked permission to sing a farewell to his tribal lands and his dead ere he be slain by his captors.

It has been stated by some writers, anent the discovery in several places in New Zealand of skeletons buried in a sitting position, that this mode of burial was not practised by the Maori, hence a " prior race " theory is set up. But the Maori did bury bodies in a sitting position, though not invariably so. When one considers the way in which the bodies of the dead were frequently " trussed " for burial, then the sitting position in burial appears to be quite feasible and also natural. Years ago I heard of skeletons being found in such a position in the sandhills on the coast at Ohau, near Otaki. The Tuhoe Tribe sometimes buried their dead in a sitting position, which they term "*tapuke whakanoho.*" (For other evidence concerning sitting-burial, see " Transactions of the New Zealand Institute," vol. vii, pp. 67, 68, 88; vol. xxxiv, p. 126 (Moriori), 129; vol. xviii, p. 24: vol. i, p. 20, of Colenso's second essay. Also, at p. 20 of vol. i of these Transactions is a reference which reads thus: " In a circular pit in the Waikato a number of human skeletons were found in an erect position, each with a block of wood on its head.")

The graves used by Natives are by no means deep—about 3 ft. or 4 ft. in depth, as a rule. As the bones are to be taken up in a few years it is perhaps better not to bury deeply, inasmuch as decomposition would be delayed thereby.

Tree Burial.

Tree burial has always been much practised by the Tuhoe Tribe, certainly since the time of one Tama-tuhi-rae, *alias* Tama-a-mutu, who flourished some thirteen generations ago, and to whom the Tuhoe Tribe attribute the originating of the custom. Tama-a-mutu instituted the custom of tree burial, it is said, because he considered it wrong to bury the dead in the earth, as the earth is for producing food. Even so, when Tama drew near his end he told his son that he did not wish his body buried in the earth, but wanted it placed in a tree. Hence, after his death his son constructed a wooden box, in which he placed the body of his sire. This box or coffin was placed up in a tree and there left. This is said to have been the first occasion on which a coffin was used in this district.

Tama-a-mutu obtained the name of Tama-tuhi-rae (Tama the brow-marked) from the fact that he used to ornament his brow in ancient fashion by marking it with red ochre (*horu*). It was also a custom to so mark the skulls of chiefs when the bones were disinterred and deposited in a burial cave or tree. There were two ways of so marking—the *tuhi korae*, or *tuhi marei kura*, consisted of horizontal stripes smeared across the forehead; while the *tuhi kohuru* was a series of red stripes running diagonally from the upper corner of the forehead downwards over the eye to the cheek. The descendants of Tama-tuhi-rae are known as the Ngai-Tama-tuhi-rae clan, generally abbreviated to Ngai-Tama. Their principal living chiefs are Te Whiu Maraki (he who captured Kereopa, the eye-swallower, at Ohaua) and Tamaikoha. This clan of Tuhoe resides at Te Waimana. I submit a genealogy from Tama-a-mutu :—

Tama-a-mutu
|
Whetu-roa
|
Te Kapo-o-te-rangi
|
Te Umu-ki-marau
|
Te Tapu
|
Tama-te-karonga
|
Te Whaka-utauta
|
Ruku-wai
|
Te Hau-rehe
|
Taonga-uru
|
Wetahu
|
Hinekura
|
Te Waka-unua

Wati.

In the following song we observe a reference to Tama-a-mutu and his institution of the custom of tree burial. This composition is termed a "*tangi tawhiti*," a singular class of chaunts by which persons are said to have been bewitched and done to death at a distance. It was composed and utilised by one Piki near a hundred years ago :—

E hine! Maru-nui i te tapu
Ka taka i o tuakana
Tu ake hoki, e hine!
I te tu wharariki
Hai whakakakakara mo hine ki te moenga
Te moenga te whita, te moenga te au
Oti tonu atu koe ki raro—e—e.
Taupae atu ra i tua o Te Wharau, e hine!
Ka wehe ko te po
Ka wehe ko te ao i a koe
Tokona atu ra ki tawhiti
He toko-uri, he toko-tea
He mapuna, he kai ure
Kai ure noa ana, e hine!
Nga tohunga i nga atua kia mate
Koi tonu nga niho ki te ngau
Na Maui i hangarau, e hine!
Tana ika tapu
Ko te whenua nui e noho nei taua
I tikina ki raro wheuriuri
Ki a Hine-nui-te-Po
Hai ngaki i te mate
I tukua mai nei ki ana karere
Ki te waeroa, ki te namu poto
Hai kakati i te rae
I te mata o te hurupiki, e hine!
Ko ta paua, ka ea te mate
O te hiku rekareka nei
O te tuna—e—i.
Takoto mai ra, e hine!
I roto i te whare papa
Ko te whare ra tena
O to tipuna, o Tama-a-mutu
I tuhia ai—e, ki te tuhi marei kura
Koia a Ngai-Tama-tuhi-rae
I whakairi ai—e
Ki runga ki te rakau
Koia te kauhau i to papa
I a Maui, e hine!
Tera ia te rua o tini raua ko mano
I karia ki te oneone ika nui, e hine!
Huriuritia iho ra, e hoa ma-e!
Ta tatau mahuri totara
No te wao tapu nui o Tane
No te awa—e, i Oatua
No runga—e, i Okarakia
No nga pinga—e, i roto i Te Kopua
Taku totara haemata
Te rite ai, e hine! ki a koe—i—a.

And ever since the time of Tama-tuhi-rae have the dead of the Ngai-Tama clan been placed in trees, and never in the earth. A tree is selected which has masses of a parasitic plant known as *kowharawhara* (an *Astelia*) growing on its branches. Among these thick masses are concealed the remains of the children of Tama.

In the above song (lament) will be noted a reference to the contest between Maui and Hine-nui-te-Po. The *whare papa* mentioned is an allusion to the coffin in which the body of Tama was placed. The expression "*mahuri totara*" (*totara* sapling) is one of many such often applied to young people recently dead. It often appears in laments. It likens the lost one to a young *totara* tree, a tree highly prized by the Maori.

In some cases the dead were placed in hollow trees, the body being wrapped up in a cloak. We have seen that the Ngai-Tama clan disposed of their dead by placing the bodies in or on trees. Other clans also did the same, but the system usually followed was that of burying bodies in the earth, or placing them on a stage, and then, when the *hahunga* or disinterment took place, the bones were deposited in a cave or chasm, or rock shelter, or in a hollow tree, or among the parasitic plants which grow on the branches of forest-trees. The *pukatea* tree, which when it attains a large size is generally hollow, is often used as a last resting-place for the bones of the dead in Tuhoeland. There are many such burial-trees at Rua-toki, one of which stands within 2 chains of my present camp at Hau-Kapua. While exploring the gulch one day I espied several skulls at the base of a *pukatea* tree, and thought that I might have some trouble with the local Natives for camping at a *tapu* spot. I quickly found out, however, that there was no need for uneasiness, as the Natives were quite ignorant of the place as a burial-ground, and denied that the remains were those of any of their people. They advanced the opinion that the bones were a *toenga*—that is, the bones of bodies that had been eaten in former times. It is, however, highly improbable that the bones of a body that had been eaten would have been treated with such respect. Rather would they have been simply thrown out on the kitchen-midden of the settlement. On the spur immediately above the burial-tree stand the earthworks of two old Native forts—Hau-Kapua and Titoko-rangi. The remains, I opine, are either those of plebeians, of whom but little notice was taken, or they belong to some other tribe. The last supposition is probable, inasmuch as Rua-toki is not ancestral land of the Tuhoe Tribe, but was gained by conquest, and Tuhoe have several times been driven off the land.

In placing bones of the dead in a hollow tree they were sometimes inserted at the base of the tree, should an opening there exist. If not, one was often found up the trunk of the tree, sometimes 40 ft. or 50 ft. from the ground. In such cases the bones would be carried up, thrust into the hole, and allowed to fall down inside the tree. Some of these trees contain great quantities of human remains. In one that fell and split open near O-potiki Captain Mair counted over three hundred skulls.

A *rata* tree at Raorao, on the Wai-riko Block, was formerly used as a burial-tree. The bodies were placed among masses of *Astelia*, with which the leaning trunk was covered on the upper side.

The bones of the dead of the Ngai-Te-Kapo clan, of Rua-toki, were placed in a hollow *pukatea* tree (*Atherosperma novæ-zealandiæ*).

A *kahikatea* tree at Nga-whakahiwawa, in the Horomanga Valley, was an old-time burial-place, as also was a similar tree at Raro-po.

When some of the Tuhoe Tribe were living at Anini, near Te Pa-puni, their dead were not buried in the ground, but placed in trees.

It is said that the remains of Mura-kareke and Tama-pokai, two famous chiefs of Tuhoe, were concealed in a hollow *rata* tree at Owhakatoro.

When Te Korowhiti died at Te Kohuru his body was placed on a platform or staging constructed among the branches of a *tawhero* tree. This making of a platform in a tree-top, on which to place a dead body, was by no means an uncommon occurrence.

Swamp Burial.

As observed above, it was a Native custom to place bodies in swamps and lagoons or ponds, the body being usually thrust down into the mud, and the water-plants, rushes, &c., would soon grow up and so obliterate all signs of disturbance. There are several such swamp burial-places at Te Whaiti—indeed, they exist in most parts of the Matatua district, being perhaps more numerous in the open country where no forest existed in which the dead might be concealed. Te Korokoro, Wai-pokere, and Te Kowhai are three of these burial-swamps at Te Whaiti. In a good many cases dead were buried near a settlement (where the graves could be protected from enemies), and when the bones were exhumed they would be conveyed to a swamp and there trampled into the mud for concealment. This method was common among the Ngati-awa and Ngati-Pukeko Tribes, who inhabit open country.

A small lagoon named Te Roto-tapu (the sacred pond), at Kaka-tarahae, near Rua-toki, has been used as a burial-place by Tuhoe for the past fourteen generations, hence it is a very *tapu* place. It is said that Toi, a famous ancestor of the Bay of Plenty Natives on the aboriginal side, was the first to be buried in a swamp, at a place called Marae-totara, at O-hope.

When Ngati-Rongo, under Pa-i-te-rangi, attacked Te Kea (who dwelt in the Titoko-rangi Fort at Rua-toki) they made a slight error, for Te Kea defeated the party and slew their leader, who was buried in a swamp.

Perhaps you are weary of swamp burial, but I want to draw your attention to a singular use of the word "*rumaki*." My informant, an old Native, said, "*Ka rumakina a Pa-i-te-rangi ki roto ki te repo.*" Here *rumaki* = to bury, a meaning not given to the word in our dictionaries. The Tuhoe people often use it in that sense.

Use of Coffins and Small Elevated Huts.

We have seen that the remains of Tama-a-mutu were placed in a box or coffin for burial. This custom was sometimes practised in former times. Bodies of the dead were put in a rough wooden box or coffin made of slabs of timber hewn out with stone axes. This would be placed on the top of a high post near the settlement, and when the flesh was decayed the bones would be taken to a burial tree or cave. Perhaps the most common method was a small erection, like a miniature house, built on the top of a high post. These were often erected within the fortified settlements of the Natives in pre-European days. We notice them in illustrations of such villages as left us by early travellers and settlers. These places within the village seem to have been used to place the bones of the dead in. The keeping of the decomposing bodies in their midst in such a manner would be somewhat too much, even for a Maori.

Coffins were sometimes constructed in the form of a canoe, from perhaps 3 ft. to 6 ft. in length. These were hewn out of wood, and were ofttimes ornamented with carving. Lids, neatly fitting, were made for them. Some very interesting and ancient specimens may be seen in the Auckland Museum. These singular coffins were used as receptacles for the bones of the dead after disinterment. They were usually placed in burial-caves, situate in secluded places. These coffins would usually be daubed with red ochre. The discoverer of the coffins above mentioned states, "The first cave contained some tons of skeletons, and several wooden images of different sizes engraved from head to toe. The largest image is about 6 ft. in length, the head and legs taking up no more than 2 ft. of the length. Each image has a hollow body with a lid for the back, and had previously been filled with bones, the lid being tied on with a kind of forest-creeper."

Williams's "Maori Dictionary" gives "*pouraka*, receptacle for a dead body, in shape like a square box, thatched over the top."

An illustration of one of these bone-coffins is given in Hamilton's "Maori Art," p. 159, where may also be seen illustrations of the handsomely carved slabs of wood erected over a chief's grave. Some fine carved slabs of *totara* wood, about 3 ft. in width, are still standing in the old fort of Mana-te-pa, at Ruatahuna. They were erected over the graves of those Natives who were shot there about the year 1842.

House Burial.

It sometimes occurred that a person would be buried in his own house, with the inevitable result that such house would become *tapu*, and would no longer be occupied, but allowed to decay.

When the inter-clan fight occurred at Mana-te-pa, as mentioned above, several of the Ngati-Ta-whaki clan were slain, including Te Whatu. The latter's body was carried to his permanent home at Oputao and there buried in his own house, which of course became *tapu*, and could no longer be used by the living. Shortly afterwards his name was given to a newly born child, who in after-years assumed the name of Paratene, which in later life was abandoned and the name of Paitini assumed. The above *pa* (fort) was abandoned after the fight, on account of human blood having been shed there. The other dead were buried within the fort, as we have seen, and the place has ever since been *tapu*.

The bones of persons buried in houses would in after-years be exhumed and placed in a burial cave or tree.

In late times, since fighting has ceased, bodies are buried in the ground, and either the grave is fenced in with a picket fence, or, as is generally the case among the Tuhoe Tribe, an old fort (*pa maioro*) is set aside for the purpose of a graveyard. Graves made in these old forts are often not fenced, as the old earthen walls and ditches prevent the entrance of stock. In some cases the body, enclosed in a coffin of rough boards, is placed on the surface of the ground and an oblong mound of earth built over it. Over this a small wooden house is erected and painted in bright colours; red and blue is a favoured combination, or white and red. At other times the coffin is buried beneath the surface and the little house built over the grave.

Colenso states in his admirable essay* that in former times corpses were sometimes placed in such little houses or huts in a sitting posture, having been tied, dressed as in life, and with its greenstone *mere* or cutting-club.

Wohlers speaks of house burial as having occurred among the South Island Natives: "The body, having been bent

* Trans. N.Z. Inst., vol. i.

together in a roundish ball (the knees under the chin, as the Maori formerly handled their corpses), was adorned, and put into a box made for the purpose, and buried in the house near the wall."* Also see "Transactions of the New Zealand Institute," vol. xxxiv, p. 574, for a similar case which occurred among the Arawa Tribe in 1882.

Old canoes were sometimes cut up to form coffins in former times. When the famous chief Te Whare-pouri died at Wellington, a part of his canoe was set up at Nga-uranga, near Wellington, as a mortuary memorial, although the body was not buried at that place.

Speaking of funeral ceremonies in ancient Greece, Max Muller says, "It is supposed that in ancient times the Greeks deposited the remains of the dead in their own houses, near the hearth, which was the primitive altar of the family.†

Articles buried with Body.

A singular custom, and a widespread one, noted the world over, and even seen among civilised peoples, is the depositing of articles in the grave. I have not been able to obtain from Maoris any corroboration of the opinion expressed by most writers on primitive eschatology—viz., that such articles were intended for the use of the departed in the spirit-world—but rather that such offerings are a sign of affection for the lost one. I have never heard that food was placed in the grave by the Maori, but the dying person was fed for the death journey, as we have seen.

It often occurs, even in these times, that cherished possessions are placed in the grave of a loved relative. I give a few instances as illustrations :—

When the child Haere-huka, a descendant of Maru-wahia, died, the body was buried at Whiria, on the Hikurangi Block, and a prized greenstone ornament was placed in the grave.

Somewhere about 1850 a party of the Ngati-Manawa Tribe, of the Galatea district, went to Hauraki in order to obtain muskets and ammunition. When they left to return home, the grandfather of Harehare Aterea stole an axe which had been placed on a grave of the Ngati-Maru people. On it becoming known to Ngati-Maru that their visitors had desecrated their burial place they raised an armed force, which, under Taraia, marched to Whirinaki, on the Rangitaiki River, to teach the children of Manawa better manners; and it was only by sending to Tuhoe and Taupo for armed assistance that Ngati-Manawa escaped a severe drubbing. But they had to pay for that axe.

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* Trans. N.Z. Inst., vol. viii, p. 115.

† "Anthropological Religion," p. 264.

We have noted that when a body was lying in state, relatives of the dead would produce their finest garments and prized greenstone weapons and ornaments, which were exhibited near the corpse. It was a token of respect to the deceased. When the burial took place most of these articles would be reclaimed by the owners, but some were buried with the body, or placed by the side thereof in the cave or tree. These also might be reclaimed later on, as when a tribal meeting took place, or a distinguished visitor arrived, or other occasion equally important in Maori eyes.

A child who died at Waikare-moana was buried with her favourite ornament, a brooch made from a crown piece, on her breast. Hence her little sister was given the name of Karauna, the Native rendering of the English word "crown."

Articles buried with a body are often recovered when the bones are exhumed, but sometimes they are placed with the bones in the burial cave or tree and allowed to remain there. These latter—weapons, greenstone implements or ornaments, &c. —were often the property of the deceased, and would not be reclaimed. "*Na te ngakau mamae tena mahi*" ("Grief was the origin of such acts").

When old Puke-tapu, of the Waikare-moana district, died, his son buried with his body a manuscript book in which were written the ancient history, genealogies, &c., of his tribe, and which was thought much of, yet it was sacrificed, and much interesting lore that it contained is now lost for ever. Max Muller quotes a similar case as having occurred in modern times, when an English poet placed the manuscripts of his own unpublished poems in his wife's grave.

Suicides were buried as any person would be who died a natural death. Wives were not buried in the same grave as their husbands, even though buried at the same time, as would occur when a wife committed suicide at her husband's death, a frequent occurrence in former times. The custom of exhuming the bones would tend to single burial, in order that the bones might not get mixed. A child is sometimes buried in the same grave as a parent or grandparent.

Male relatives of the dead prepare the grave and bury the body. They are *tapu* while so engaged, and the *whakanoa* rite is afterwards performed over them in order to remove the *tapu*.

The Tuhoe Tribe do not seem to have had any burial-grounds in former times — *i.e.*, where a number of persons would be buried—for reasons already stated. Matters are very different now that parties of armed ghouls no longer roam the land seeking whom they may devour. Hence, also, the custom of exhuming the bones of the dead is falling into desuetude.

Bodies of the dead were carried to the grave on a litter or bier formed of poles. They were borne head first, whereas in so carrying a living person the head is always kept up-hill.

Among coast-dwelling tribes, more especially where no forest is near, it was a common thing for sandhills to be utilised as burial-grounds. Where dunes of pure sand exist, devoid of vegetable growth, the disturbance of such would leave no traces longer than a few hours, especially so were a wind blowing at the time. Such a burial-place is the ancient one at O-pihi, among the sandhills near the beach, and just across the river from Whakatane Township. This place has been used as a burial-ground for centuries past. The saying "*O-pihi whanaunga kore*" (O-pihi the relationless) is applied to it. "Our ancestors Tama-ki-Hukurangi and Rakei-ora were buried at O-pihi. That was the permanent burial-place of our ancestors from ancient days down to the present time. Afterwards Putauaki (Mount Edgecumbe) became a famed burial-place. In later times the dead were buried in swamps, in lagoons, on hills, in valleys. Hence burial-places became much more numerous."

In ancient times no large burial-grounds existed anywhere near Native settlements, but when disastrous epidemics were introduced by Europeans, then such great numbers of people died that they were buried near the village homes, and many were never exhumed. Sometimes the death-rate was so appalling that the survivors fled in terror to seek a new home, often leaving many dead unburied behind them.

Burial-grounds are *tapu*, and are avoided by Natives. They do not like passing such places after dark, for they have an idea that the spirits (*wairua*) of the dead are abroad at such a time. How they reconcile this belief with another that spirits of the dead descend to the underworld they are not able to explain.

When a young Native workman was killed by a rolling log on the roadworks at Ruatahuna, Natives disliked passing the spot where the accident occurred, after dark, for some time afterwards, for fear of encountering the ghost-spirit of the dead. Any who so passed after nightfall would sing lustily a Native song while so passing. His companions objected to return to work at that spot, whereat the deceased man's grandfather proposed to *huki te toto*—*i.e.*, to remove a portion of the dead man's blood on a stick and, by an incantation or charm, to remove the *tapu* from the spot.

A burying-place is termed "*urupa*" or "*toma*." A burial-cave, where exhumed bones of the dead are deposited, is called a "*whara*," or "*rua koiwi*," or "*ana korotu*." The expression "*whara*" is sometimes applied to hollow trees in which bones are deposited. At Te Tawa-a-Wairoto, near Rua-toki, is a burial-cave where lie many of the dead of Tuhoe. On some of the skulls the *tuhi marei kura* (see *ante*) may be seen, marked with red ochre.

The burial-places of enemies, or of a conquered or vassal people, received but scant respect at Maori hands. When the Rua-wahia Block case was before the Native Land Court, Mikaere stated in his evidence that "The Ngai-Tuaraitaua people came from Waitaha, from O-tama-rakau, and settled at O-kataina and at Rua-wahia. They put their dead in a cave named Rau-piha. We used to play there as children, breaking the skulls with stones. That burial-cave was not of our people. Ngai-Tuaraitaua were slain by the descendants of Apu-moana."

How different the case when the burying-ground contains your own dead! "A thing much dreaded by the Maori people is a burial-cave. No one trespasses there, no person desecrates the spot. It is a thing feared. Should a person trespass on that place, severe affliction will affect such person. The bones of the dead will turn upon him and afflict him sorely. Although the person may deride danger from such an action, yet he will not survive. I say, though he seek the priest in order to be saved, yet he will not survive. Those bones are destroying him."

The *tapu* from touching a dead body was extremely strong and prohibitory. It rendered the person unclean, and unable to mix with his family or fellows until he had been purified—the *tapu* taken off him. As a source of such defilement the touching or handling of corpses was pre-eminent, as it is among the Parsis. The special class of Nessusalar, or "unclean" bearers of the dead, among the latter people were also represented among some tribes of Maoriland, where certain persons had assigned to them the task of handling dead bodies (usually one such person in each village), and these persons were continually "unclean" (*tapu*), so much so that they were forced to live as outcasts from tribal society; shunned by all were they, compelled to gnaw their food as dogs do, on the ground, not being able to touch it with their thrice *tapu* hands.

Whakanoa (Removing the Tapu).

Near every Native village in former times a pond, spring, or brook was utilised as a place where sacred rites were performed, and set aside for that purpose. These waters would not be used for domestic purposes. It was known as the "*wai tapu*" (sacred waters), or "*wai whakaika.*" Lifting the *tapu* from persons was often done at such places. This custom still obtains among the Tuhoe Tribe. When taking the *tapu* off bearers and burial parties, the person who officiates as *tohunga* (priest, shaman) conducts the party to the waterside and bids them take off their clothing and immerse their bodies in the water, after which he recites a *karakia* (charm, incantation, spell, invocation) in order to lift or dispel the *tapu*, and gives the parties a cooked potato to eat. The persons are then *noa*, or free from *tapu*, and may partake of food and mix with their fellows. Cooked food, it may be observed, is a most polluting thing, the direct antithesis of *tapu*, hence it is used in these rites to destroy or overcome the *tapu* (uncleanness or sacredness). To smoke a pipe of tobacco has the same effect, tobacco being termed food (*kai*) by the Maori, hence it is sometimes used in that way, generally perhaps in rites of minor importance. This rite of *whakanoa*, however, was performed with more ceremony in former times.

A portion of the food cooked for the ceremonial funeral feasts—*i.e.*, at the burial of the dead, and at the exhumation of the bones—was specially sacred. It was for the chief officiating priest, and perhaps the first-born son of the chief (*ariki*) line of descent of the tribe, such a person being termed a "*matamua*" (first-born); also, perhaps, the food reserved for those who handled the dead body or bones was called by the same name—viz., "*popoa*."

The *whakanoa*, or making-common rite, performed over those who handled a corpse, or bones of the dead, was termed "*pure*." It dispelled the *tapu* and purified the operators.

A portion of the *popoa* or sacred food was offered (*whangaia*) to the dead body by the priest (*tohunga*), who placed it to the mouth of the corpse and withdrew it. The dead person was supposed to absorb the *ahua* (semblance) or *aria* (likeness, resemblance, imaginary presence, form of incarnation, &c.) of the food. One authority states that the priest merely waved the food in the direction of the mouth of the corpse ("*Ka poia te kai ki te waha o te tupapaku*"), repeating as he did so,—

Tuputuputu atua
Ka eke mai i te rangi
E roa e
Whangainga iho
Ki te mata o te tau
E roa e.

Now, this is a singular thing: The above is a portion of an invocation to the stars, which was repeated at the "first fruits" ceremony in former times. Tuputuputu is, I believe, one of the Magellan clouds. All the principal stars are mentioned in a similar manner in the full version of the above. As it was an invocation to cause the stars to provide a plentiful supply of foods, I fail to see its connection with burial rites. My informant may have been in error in giving it in the above connection, yet he is the most learned of the Tuhoe Tribe in their ancient history and ritual, and has taken part in the *pure* ceremony. The only point of light visible to me is this: The invocation was to induce the stars to send bounteous crops, as also to cause birds, &c., to be plentiful, but likewise to prevent food-products being afflicted by any disease, &c. The old-time priests may have endeavoured to ward off disease or death from the living at such rites as the above. It is certain that at many different functions in ancient times priests performed the *tira ora* rite, whereby to protect and retain the health, prosperity, welfare—physical, mental, and spiritual—of the tribe.

At the *pure* ceremony the chief mourner had his hair cut by a priest with a flake of obsidian. This was done at the *wai kotikoti* or *wai whakaika*, a sacred stream, spring, or pond whereat religious rites were performed.

The term "*horohoro*" is also used to denote a removal of *tapu*, or a portion of the rite. "*Horonga*" is applied to food eaten by the priest during the above ceremony.* "*Horohoro*" in the Paumotuan dialect signifies "soul, spirit."

I have heard it stated by a Native that bodies of persons of low social position were sometimes not buried, but simply thrown aside, with the added remark, "*Nohea ra e rongo nga tupuna i te haunga*" ("Our ancestors would not mind the stench thereof").

Cremation.

Cremation was frequently practised by the Maori in former times. It was practised by those tribes that lived in open country where they had difficulty in concealing the bones of their dead from enemies; also by war-parties traversing hostile territory, who would cremate their dead, but often preserved the heads and carried them back home. At least one case is on record where a war-party, reduced to desperate straits during a foray, burned their wounded to prevent them falling into the hands of the enemy.

An interesting article on cremation amongst the Maori people will be found in the "Journal of the Polynesian Society," vol. iii, p. 134.

In the Matatua district cremation was performed in some secluded spot, which remained *tapu*. The ashes were not preserved in any other way.

When Tu-korehu raided Rua-tahuna he lost Te Tiroa, a chief of his party, who was slain by Ngati-Tawhaki. The body of the slain man was cremated lest it be found and eaten by the Tuhoe people. As a relic of the good old days we have still among us in Tuhoeland two old men who have taken part in

* Williams's "Maori Dictionary."

cannibal feasts. Even when a war-party was victorious they often were compelled to burn their dead on account of the difficulty of carrying the bodies home.

Those persons who died of *kai-uaua* (? consumption) were cremated by the Ngati-Awa Tribe of the Bay of Plenty district, and the ashes buried, in order to prevent any other person being affected by the disease.

The Maori has a belief that the priests of former times held wonderful powers. Observe the description of the *whakanoho manawa* rite, as given by the Tuhoe people, and included in the late Dr. Goldie's paper on "Maori Medical Lore," in vol. xxxvii of the "Transactions of the New Zealand Institute."

The following incident was given to me by Himiona Tikitu, of Ngati-Awa, as having occurred two generations ago: "There was a large meeting of Te Awa-a-te-atua. All surrounding peoples attended it. Tawharau, of Nga-maihi, was there. The daughter of Rangi-takina saw him and deemed him handsome above all other men. She strove to gain him as a husband. He declined, saying, 'You are far above me in social position.' However, the woman overcame his scruples. Then things became interesting for Tawharau. Rangi-takaina and his people objected to the union, and put an end to it by slaying poor Tawharau. Nga-maihi heard of it. They went and dug up the buried body to the recited charms of the priests. They bore it to the Kupenga Fort (situated on the bank of the Rangi-taiki River, at Te Teko). They deposited it at the *tuahu* (sacred place where religious rites were performed). Then the priests gathered to challenge or incite the spirit of the dead man to turn and avenge the death of its body. Then the dead returned to life for a brief space, the magic spells were worked, the spirit rose to its dread work. Then the body returned to the clutches of death and was buried. Ere long Rangi-takina and the other slayers of Tawharau were no more. The body of Rangi was placed in a European goods-case used as a coffin, and taken to Mount Edgecumbe for burial. People gathered to drag the coffin up the steep side of the mountain. Nga-maihi were there. One of the latter, Meremere by name, rose to chaunt a time song for the hauling. It was a *tau waka*:—

Te hiwi
Te maunga e tu mai nei
E tupa
Hoi eke!
E tupa
Hoi eke!
Tupato
Hoi eke! &c.

Pukaka, axe in hand, jumped for Meremere, intending to kill him, but Nga-maihi closed in and prevented him. The singing of the canoe-hauling song was in disparagement of Rangi-takina; it likened his body to a canoe. Enough! That party crumbled away, each to his home, each to his home."

It often occurs that a Native will claim a small piece of ground where a parent or ancestor of his was buried or slain, although he has no real right to such lands, either ancestral or by conquest, and such claims are often agreed to by the Native owners of the block. When the Whaiti-nui-a-Toi Block was before the Court, Parakiri, of Ngati-Manawa, stated in his evidence, "I claimed a small part of Tahu-pango where my ancestor Taupoki was buried. Ngati-Whare had handed over the piece when my father told me that Taupoki's bones had been exhumed and taken away. I then waived my claim."

There are many singular methods by which the Maori of yore sought to discover the cause of death and to avenge it. The following is another specimen, and the death of the wizard would be compassed by means of magic spells: "Another custom of the Maori people: A person dies and is buried. If it was believed that his death had been caused by witchcraft a stick would be procured, over which magic spells were uttered, and it was stuck in the centre of the grave and left standing there. Now, should that stick descend (of its own accord) into the ground, to the body which lies below, then not one of the persons who caused his death will survive: they will all perish. Such is the method adopted by the Maori people in order to avenge a person destroyed by witchcraft."

In regard to the Earth taking back her children (man) to her bosom at death, a similar idea may be discerned in the Rig-veda: the earth seems to have been invoked "to receive the dead, as a mother receives her child." Observe a quotation at page 256 of Max Muller's "Anthropological Religion"; also, at page 254, an account of purification by immersion of the body in water after funeral rites. Note the quotation, "They should not cook food during that night." This is Maori. Funeral and many other religious rites were performed by the Maori early in the morning, and none were permitted to partake of food until the ceremony was over and the *tapu* removed. We note in translations of and writings upon these ancient Oriental works, as given by Max Muller, that fire and water were used for purification, just as they were among the Maori. In ancient Greece this custom also obtained: "It was usual at Athens to place a vessel full of water near the door, so that those who had become impure by entering the house [of the dead] might purify themselves."

I here give a few notes concerning a death and burial which I myself witnessed in these parts some nine years ago. When camped in the sylvan vale of Te Whaiti-nui-a-Toi, in 1896, the Tama-kai-moana clan, of Maunga-pohatu, sent three children to Te Whaiti to attend the Native school at that place. Some time afterwards one of them, a little girl of seven or eight years of age, died at Te Whaiti, and her body was carried back to Maunga-pohatu to be buried with her ancestors. It was in this wise: The old patriarch of the clan accompanied the children, and to a certain extent commended them to my care, hence they spent much of their time at my camp. The fever came to the cañon of Toi, and the brown-skinned children of Toi went down before it. Pepuere, of Ngati-apa, and his wife broke out the trail from Te Whaiti. But a few days and bright-eyed Hara followed them in search of the Hidden Land of Tane. Then little Hineokaia passed out on her journey to the swirling weed of Motau, and, lest they be separated, took with her her infant brother, to leave the descendants of Tamatea the Cannibal wailing on the storm-lashed peak of Tara-pounamu. Timoti, of Marakoko, followed his playmates, and Wairama, of the daughters of Kuri, abandoned the world of life. Scarce passed a day but we heard the gun fire which betokened yet another death, and the world was dark to the people of the great forest of Tane. Then Marewa went down into the dark valley and wrestled for many days with death. The *kutukutu ahi* came — the delirium of fever, a fatal sign to the Maori—and little Marewa was called by her friends who had gone before.

I was writing in my tent one day when I heard a volley fired just across the river, and I knew that Marewa was about to lift the world-old trail trodden by all the sons of man, even from the days of Tura and of Maui. When I reached the place I found her lying in a tent a little distance from the settlement, her mother by her side, the people collected before the tent. I could see that the child's end was very near. Her father said to me, " Friend, your grandchild has departed." And then, just before she passed away, he bade her farewell from where he stood outside the tent: " Farewell, O maid! Farewell. Go to your ancestors who await you. Go to your playmates. Return to your mother, to Maunga-pohatu, who brought you forth to the world of light. Go to the world of darkness. Farewell," &c. The mother sat wailing by the child's side. Warned by the guns, the people of adjacent places kept coming to join in the lamentation. Each one as he or she approached would cry out, " Farewell, O maid! Farewell." The end came soon. As her mother sat with her hand on the child I saw the poor suffering mite draw her last breath, and pass out over the edge of the *rohe potae* n search of another world.

Some days before the child's death her parents arrived, and her father began to prepare for carrying the child back to her home at Maunga-pohatu, that she might draw her last breath at her home and on her own tribal lands. Knowing the extreme roughness of the track, and judging that such carrying would cause the child much suffering, I objected strongly, saying that she should be allowed to die or recover where she was. I gained my point, but much offended some of the child's elders by my interference. As the child passed away an old woman sitting near raised the mournful long-drawn wail for the dead, and then many voices were raised to bewail the loss of Marewa-i-te-rangi. It was principally a wordless wail, but every now and then one or another would give a few lines of some old dirge.

The people of Te Whaiti wished the child to be buried at that place, but her people objected. Therefore a coffin was made of rough boards, the body placed in it, and the coffin tied on to a bier for carrying. Young men of the district offered their services as carriers, two carrying the bier, bearers changing every mile or two. The parents of the child asked me to accompany them to their home and see the last of their child. I could not leave with them, but knew that it would take them three days to carry the child home, whereas I could walk the distance in a day and a half. So I delayed starting until they had covered half the distance. The party stayed a night at three different Native villages, and at each place the mournful wailing was indulged in, as also speech-making. And the people of each place asked that the child be buried in their *urupa* (burial-ground), but the father objected. The family with whom the child had stayed at Te Whaiti accompanied the party, at, I think, the parents' request.

The last night on the road was passed at Rahitiroa, and I caught up to the party just before they arrived at that isolated hamlet. As we wended our way along the forest range, about three-quarters of a mile away, our party fired two guns to let the village people know we were near. They had before been apprised of the probable date of the arrival of the party. As we passed down the bush-covered spur leading down to the hamlet I saw old Hopa, of Hamua, cut a stick and hand it to one of the women of our party. As we approached the plaza we saw the people of the village assembled thereon, while men were firing guns frequently, some standing on the roofs of outhouses as they fired. As we halted about 30 yards from the collected people the coffin was placed on the ground and the wailing for the dead was proceeded with. After this was over our party sat down, and the leading men of the place rose one by one and made speeches anent the death of the child and death in general. Then the principal men of our party did the same thing.

Now, when we marched on to the plaza the chief man of the place was standing in the ranks opposite. At once the woman of our party who had been provided with a stick walked up to him and struck him sharply across the shoulders several times. He took not the slightest notice, but stolidly continued his wailing. The cause of this was the fact that this man had proposed that Marewa be treated by a local *tohunga* (shaman), a crazy man who treated patients as being afflicted by *kehua*, or spirits of the dead. Although the child was not treated by this ruffian, yet the proposal for him to do so was deemed by some Natives to be the cause of her death. Also, the beaten man's own daughter had died but a few days before our arrival, and it was thought by some that she had been bewitched by the same old humbug. Had not the long-armed law of the white man been reaching out across the wild forests of Tuhoeland at that time, it is highly probable that the old warlock would have died suddenly of lead-poisoning.

At this forest hamlet we were treated to an illustration of the ancient custom of *muru*, or *kai taonga*—*i.e.*, the taking forcibly or demanding payment for some injury or loss sustained by the person or persons from whom such payment is demanded. A girl of this place had been assaulted some days previously, hence our party demanded compensation. Why a people should pay for the privilege of being afflicted by some trouble is a somewhat difficult problem for the European mind to solve, though it appears to be clear enough to the Maori. Possibly it was looked upon as a punishment for them not having looked after the child better. It is a custom that, presumably, could only obtain among a communistic people. Anyhow, the visitors left the richer by two horses, two rolls of print, some new clothing, several greenstone ornaments, and 5s. in silver. Apparently the latter represented the amount of ready money in possession of the subclan.

A considerable amount of speech-making was indulged in. In the course of his speech one of the village people said, "Welcome, O maid! There are none here to welcome [beckon] you to the plaza. All your Maori people are dead. Your lands have become digging-places for the white man" [alluding to the Government road-works then in progress]. A woman murmured, "*Ei! Moumou a Marewa*" ("Marewa is wasted"—*i.e.*, reared to no purpose). The old chief of Maunga-pohatu (grandfather of the dead child) rose: "Friends, the shadow of death has again come upon us, the death that came to man in the days of Maui of old, in the days when man was young upon the earth. It has ever remained with us, even that all men, great and small, are caught in the snare of Hine-nui-te-Po. There is no escape from it. But this dying of our young people is a new thing. In former times our people did not die so—they scarce knew disease; they died on the battlefield or of old age, they knew no other death. These diseases which slay our people were brought by the white man. They brought the epidemics which raged in the days of our fathers, the *rewharewha* and the *kurawaka*, which slew many thousands of the Maori people. Now we are afflicted by the *whaka-pakoko* (fever). Friends, we have prayed long to the God that health and strength be given to the Maori people, that we may retain life. But the scourge never ceases, it continues and continues. Therefore have I ceased to pray for health and vigour for our people; I now pray that we old people may be taken, but that our children be spared. But methinks I see before me the end of the Maori people. They will not survive. For we can see that our people are fast going from the earth," &c.

Next morning our party started on the last day's march to Maunga-pohatu, over extremely rugged forest country where the work of the bearers of the bier was no sinecure. When we reached the summit of the high, bleak range of Te Whakaumu a halt was made at the old *taumata*, or resting-place, used by these foot-travellers of the great forest for centuries past. The snow and cold sleet are driving fiercely across the sullen, exposed summit, yet the bier-bearers are stripped to the waist and perspiring profusely. The ascent of Te Whakaumu is no joke. When relieved they wrap blankets round their nude bodies and drop behind the bearers. Through a break in the driving storm we see the great rock bluff of Maunga-pohatu far above and ahead of us. The mournful wail of the lament for the dead sounds through the drifting snows. The mother of the dead child is crouched upon a rock near by, and gazing across the forest ranges at the storm-lashed mountain. She is greeting the sacred mountain of the fierce Tama-kai-moana clan, the enchanted mountain of many a wild legend, that, as Maori myth has it, gave birth to the dark-skinned people who dwell beneath it, and gathers them to her stony bosom in death. For she is the *mana* of the clan—she is the mother of the Children of the Mist.

The mother is in the *whare potae*. She is mourning for her child, and greeting the landmarks of her home. It is a combination of mother-love and the love of primitive man for his tribal lands. Now the summit of the mountain is suddenl covered with a white pall of mist. An old man said, "Th mountain is greeting for her child." The parents of the chil are a little apart; they have chaunted a lament for their child and greeted their mountain home. Then, as the mountain-brow becomes obscured by the mists the whole of the people give voice together in an ancient dirge of their race The bitter sleet and snow, fierce-driven by the winds, pelt the mourners unmercifully. Through the drifting scud we see the great cliffs far ahead, wherein are the caves of the dead, where lie the bones of many generations of the children of Potiki. And then, with the storm fiends lashing us, we go down into the darkling valley below.

When we reached the narrow valley where, in times long passed away, the men of Tuahau were done to death, we who were not bound by *tapu* indulged in a meal; but the bearers of the child were not allowed to partake of food until the shades of night should fall, and the bereaved parents, being in the *whare potae,* were also forced to go foodless. They sat apart from us "common" people, and full well do I remember the indignant refusal of the bereaved mother to partake of a pannikin of tea which I offered her. *Mea culpa!* Of a verity my sins be many.

When our party emerged from the forest into the clearing and saw, a mile below us, the village of the Tama-kai-moana clan, a few shots were fired to let the people know of our arrival. They fire several shots in return. Then we see the people rapidly collecting in the plaza, and long, wailing cries come to us on the clear mountain air. Descending by rugged ways we reach the stream below, where we halt and form into solid column, the bearers of the bier being in front. In that formation we march slowly up the slope towards the village. When about half-way up the challenger (*wero*) leaps from cover behind a stump. Naked to the waist, clad but in a scanty kilt, face painted, hair adorned with feathers, and brandishing a double-barrelled gun, he advances towards us, leaping from side to side, making hideous grimaces, lolling out his tongue, and emitting deep-toned grunts as of defiance. When within about 12 ft. of the front of the slowly advancing column he rapidly fires both barrels of his gun to right and left, turns to his right, and walks quietly back to the hamlet. The column takes no notice of this exhibition, but marches slowly onward, with guns at the trail, looking straight before them and downward. Meanwhile volley after volley is being fired in our direction from the village, where many of the men are armed with breech-loaders. Loud cries of "*Haere mai!*" are mingled with a dozen different laments. As the head of our column reaches the fence which encloses the plaza the armed men are crouched behind it. Thrusting their guns through the palisades they fire a final volley over our heads, and then retire to take their place among the village people who have gathered to receive our party. Then followed a long period of weeping (*tangihanga*), which we have already described. This lasted for about two hours (a very long *tangihanga*). After this the village people —*i.e.*, some of the leading men—stood forth and made speeches in a loud voice. One big-framed bushman fiercely denounced the old chief for taking the child away to die through contact with the white people. "I do not stand forth to welcome you, but to blame you for the death of our child. You took her away to bring life to the Maori people! Not so: it was to bring death. We sent her living body forth from here: the semblance alone returns. We saw you take her alive and well: you return us a piece of wood [the coffin]. Why do you bring this piece of timber here? I do not want it. Take it away and give me back my grandchild." So he continued for some time; and then, dropping the fierce tone of voice, he greeted the child as though she were still living: "Come back, O maid! Come back to the home of your fathers. Return here to Maunga-pohatu, to your mother who greets you, greets you by the sign of the drifting mists. The breath of life has departed from you, the personality alone remains. Behold yon mountain!—the mountain that brought you into the world of life, and which greets her child as she returns to rest with her ancestors. Welcome. Come, child, though you be covered with the garment of death which descends upon all mankind, come and sleep with your fathers who await you," &c.

That night the coffin was placed in a rude shed constructed for the purpose on the plaza. The mother and aunt of the child remained all night with the coffin. Every time I awoke during the night I could hear them wailing for the dead, crooning forth old laments in tones most doleful to hear.

Mourning and speech-making were continued the following day. The parents and aunt (the latter seemed to act as chief mourner—her part was the *tangi whakakurepe*) took food only after darkness fell. The young men who had carried the child from Te Whaiti had the *tapu* removed from them at an adjacent stream in the manner already described.

The second night of our stay, two of our party slept in a shed adjoining my own camp. I heard them rise about midnight and leave the place. It appeared that they had heard a whistling sound which frightened them, as they imagined it to be made by the ghost-spirit (*kehua* or *whakahaehae*) of the dead. Therefore they took up their blankets and fled to the large sleeping-house, where most of our party were, and there passed the remainder of the night.

On the second morning after our arrival the child was buried

The grave of one of her great-grandfathers, who flourished during the first half of the nineteenth century, and who had been buried at one side of the plaza of the village, was opened and the child laid within. The people were gathered together about 40 yards from the grave. The burial party were, of course, all *tapu*. When opening up the grave, one of them took out the skull of the old warrior who lay therein and held it up to the view of his descendants, from whom arose a long moaning wail at the sight. After the burial the *tapu* was taken off the burial party.

That night all the visitors were called to assemble within the meeting-house. On entering we saw that all the dead child's possessions, except her ordinary wearing-apparel, had been collected and displayed in the middle of the room. There were also other articles, presented by her elders. The items comprised beautiful feather cloaks; greenstone—both worked and polished ornaments, and blocks of the rough, unworked stone; cloaks and capes woven from dressed and dyed flax-fibre; as also other articles, together with £10 in money. All these things, as also the horses on which the child had been carried on divers journeys, were presented to the people with whom she had lived while at Te Whaiti, those who had tended her during her illness, and those who had brought her body back home. Farewell speeches were made by the village people that night to our party, who were to leave next morning, with many greetings to those who had been kind to the child.

When the sun climbed over the rugged front of Maungapohatu next morn I lifted the back trail for the cañon of Toi, amid the farewell cries of the bush folk—"*Haere. Haere ki a Marewa.*" ("Farewell. Return to Marewa"). Although actually leaving the child, yet to the Native mind her semblance and personality were ever with me and at my camp. Looking back from the summit of the range, before entering the forty-mile forest, I saw the mother seated opposite to her child's grave on the cliff-edge, and swiftly came back to me the words of Hopa of Hamua: "*Kua riro to tatou kura i toku ringa. Hai konei ra E hine! Hai konei. Hai konei. Hai konei.* ("Our treasure has now left my hands. Remain here, O maid! Farewell. Farewell. Farewell.")

A remark omitted: In these days of the white man the Maori prizes highly a photograph of a deceased relative. Having a good many photographs of Tuhoe Natives in my camp, people come and ask to see a photo. of some relative who has passed away. This they will weep over for a while and then go away apparently satisfied. A Native asked me to photograph his dead daughter as she lay on the bier. When finished, I left it with the parents at their home. They made no sign during my brief stay, but I had not ridden a quarter of a mile down the track before I heard the mournful wail for the dead raised. The old people here sometimes weep profusely at sight of a photograph of Te Kooti, or "Te Turuki," as they term him.

The Maori of yore preferred to die in battle. He disliked the idea of perishing slowly of natural decay—"*Engari kia mate a ururoa te tangata*" ("Rather let man die like the *ururoa* shark, fighting to the last").

At the lamenting for a dead man his widow is a prominent mourner. She walks about during the *tangihanga* weeping and indulging in the *tangi tikapa* (see *ante*). Near relatives of the dead, who take charge of the corpse, receive the choicest food, albeit they eat but at night. They are termed the "*whare mate,*" or "*kiri mate.*"

The mortuary memorial is occasionally a double one—in this way: When Takua, of the Ngati-Kahungunu Tribe, was slain at Nga-huinga, a wooden post was set up, and a pit (*pokapoka*) dug at the spot where he fell. Some of the memorials erected for chiefs were carved in a most elaborate manner.

I have heard an old Native say that weeping for the dead was not so common in pre-European days here as it has become since, and that it was principally performed over a person slain by treachery, not so much over those who were slain in fair fight or who died a natural death. It may be so, but I have my doubts.

On the return of a war-party there would be a *tangihanga* for those who had fallen.

W. Wyatt Gill has recorded the "trussing" of the body for burial in Mangaia (Cook Islands), with many other interesting facts; as also the case of a person who remained in the *whare potae* for seven years, for an only child.

In some cases members of a war-party would carry home the bones of their dead, as well as the head.

There is among the Maori no feeling against uttering the name of a person lately deceased.

A few weeks ago a Native was taken ill at Rua-toki, and it was thought his end was near, hence the people started to carry him to Matata, thirty miles away, that he might die among his own people and on his tribal lands. On reaching the Rangitaiki River, however, he died, but the bearers took his body on to Matata, where the mourning and burial took place.

Exhumation (Hahunga).

The exhumation of the bones of the dead usually takes place about four years after burial. It, however, often occurs that the dead are allowed to accumulate for years, and then a meeting of the peoples to whom such dead belong is called for the purpose of taking up the bones and conveying them to burial caves or trees. This ceremony has ever been deemed by the Maori an extremely important one, and those who disentomb the dead or handle their bones are under very heavy *tapu* until the ceremony is over and the *tapu* removed by means of the *pure* rite. It often happens that some of the dead have been buried for a space of time considerably longer than four years. Others, again, may not have been buried for more than half of that time, or even less.

Many people collect at the larger meetings held for this purpose, caused by different clans being related through intermarriage, and by the fact that Natives enjoy these meetings on account of the facilities they afford for social intercourse. There is much wailing for the dead when the bones are disinterred. At an exhumation which took place in this district some time back there were five men engaged in disinterring the bones, under an elderly man who acted as *tohunga* (priest, adept). As the delvers took out the bones they were wiped with handfuls of grass by the principal person of the party, and laid aside in little heaps, the bones of each body being kept separate. One of the bodies, that of a child, had only been buried a few months, and many objected to its being disentombed, but they seem to have been silenced. This *hahunga* was a lengthy one, and continued for some time, hence the working party could not go foodless for the period of the ceremony, hence just before each meal they had to be cleansed from the dread *tapu* before they could eat. They went down to the riverside and immersed their bodies in the waters thereof each time; the *karakia whakanoa*, or cleansing invocation or charm, would complete the removal of *tapu* until they recommenced their task. In days of yore this ceremony was always conducted by the priests, assisted by their pupils (neophytes). The bones of each body were wrapped up and placed on a stage, termed a "*whata puaroa*," or "*atamira*," where they remained until all were disinterred, and were then taken away and deposited in the burial-cave. This latter task fell to the lot of the relatives of the dead.

The priests erected the stage on which the bones were placed, and also put them on it, repeating as they did so,—

Ka iri ki te whata no Hotu
Hotu tu nuku, Hotu tu rangi
Hotu tu kai tau.
Ka iri ki te whata
Whatu nui, whatu roa
Ka eke ki te whata
Whatu Tangaroa.

The following is a charm used by the Ngati-Awa Tribe at such times :—

Ka iri ki te whata
O Hotu nuku, o Hotu rangi
Hotu tapoa nuku, tapoa rangi
Tu kai ure
Kai ure te po nunui
Kai ure te po roroa
Hikitia mai te manawa o Tane
Ara mai te mana o Tane
Kopia mai te mana o Tane
Ka ngau ki tua, ka ngau ki waho
Toro hei !

The following is also from Ngati-Awa :—

Ka iri ki te whata
O Hotu nuku, o Hotu roa
Hotu tatakina te mata o Tunui
Hotu tukua mai te rehu tai moana
Ka whanatutu rangi
Whakapua Tutara-kauika
Te wehenga kauki
Ka iri ki te tarana o Tane-i-te-kapua
I te kapua nui, i te kapua roa
I te kapua matotoru
I te Tatau-o-Rangiriri
Turanga maomao
I tupu ki tua, tupu ki waho
Ka ea nga mahi, ka ora
Ora ki tupua, ora ki tawhito
Toro hei !

These exhumation ceremonies are still conducted among the Tuhoe Tribe with considerable ritual. At one such which took place in this district a few years ago the proceedings lasted for two weeks. This was on account of two children having died at the village while the *hahunga* was in progress, which prolonged the function. Then might be seen on one side of the plaza a *tangihanga*, or weeping for the dead, in progress, lamenting the dead with tears and wailing, while just across the open square a number of Natives were enjoying themselves, making merry with song and dance and shrieks of laughter.

Persons of low birth were not allowed to take part in disinterring the bones of the chieftain class. Persons so engaged cannot eat or drink until the *tapu* is taken off them. The visiting peoples at these exhumation meetings bring presents, termed "*taonga kopaki*" (see *ante*), for the relatives of the dead.

Supposing that some Natives of another tribe, say Ngati-Awa, were to die among the Tuhoe Tribe and were buried there, when the proper time came Tuhoe would disinter the bones, and a party of them would carry the bones to the homes of the dead in the Ngati-Awa country. Those of the party who actually carried the bones would be *tapu*. Others would be a sort of escort. Some women would probably accompany the party, and would act as cooks on the journey. The party would also take some presents, such as greenstone ornaments (the jewels of Maoridom), &c., for the relatives of the dead. Ngati-Awa would not make any return presents, but would act in a similar manner should any of Tuhoe be buried on their lands. Relatives of the dead retained the *taonga kopaki*. Some of Ngati-Awa might attend the disentombing of their dead by Tuhoe, or none of them might be present.

Many years ago a party of Ngati-Kahungunu Natives from Te Wairoa, while on a visit to Rua-tahuna, fell victims to an epidemic which ravaged that remote vale. Some years after the Wairoa people asked Tuhoe to disinter the bones and convey them to Te Wairoa. This was done, and the Wairoa Natives collected at one of their villages in order to receive the party. As the latter entered the village and marched on to the plaza, those bearing the bones were in a state of nudity, to show that the *tapu* was on them. They merely wore a rude *maro* of green branchlets fastened round the waist. Rumours were abroad that the Wairoa people were armed and were going to fire on the party—a most extraordinary thing to do under the circumstances, but the old-time enmity between the two tribes was still keen at that time. They may have suspected witchcraft (*makutu*) as the cause of their friends' deaths. Just before the party entered the village, an old woman, who was performing the *powhiri* (welcome) from a small hill hard by, called out, "*Kia tama-tane te haere*" (*i.e.*, "Be cautious how you advance"), and Tuhoe thought that things were about to happen. However, nothing untoward occurred.

The funeral feast held at the *hahunga* (disinterment) of bones of the dead was an important affair to the Maori people, and was accompanied by much ritual, repeating of invocations, incantations, &c. For some time prior to the ceremony the people would be busy at cultivating extra food for the occasion, and also preserving various kinds, as birds and fish. As the time for the *hahunga tupapaku* drew near, all available kinds of fresh foods would be obtained for the ceremonial feast. These foods would be cooked in different ovens (steam-ovens), each one having its distinctive name, and its contents being for certain persons only. Some of these ovens were intensely *tapu*, as the small one for the chief priest, and that for the eldest son of the high chief's family. This feast was a part of the *pure* or *tapu*-lifting rite. All obtainable vegetable food, as sweet-potatoes, *taro*, greens, &c., were cooked in these steam-ovens (*umu* or *imu*), together with fish, birds, and, as a special luxury, the flesh of the Native dog. Rats were often preserved in fat and so eaten.

Among the Tuhoe Tribe there were six different ovens prepared for the *pure* function—*i.e.*, for the general feast. The function itself was often termed "*ahi pure*" (*pure* fire), sacred fires being used in many Maori rites, which often are termed "fires," as "*ahi taitai*" (the *taitai* fire or rite), "*ahi rokia*," &c. The term "*umu*" (oven, steam-oven) is often used in the same manner, as also is its variant form "*imu*"—*e.g.*, *umu pera*, *umu pongipongi*, *imu kirihau*, *imu wa-haroa*, &c. The ordinary term for a steam-oven is "*hangi*," which, however, Tuhoe never apply to these sacred ovens, or ovens used in connection with their numerous religious rites. Such ovens they invariably term "*umu*." The Ngati-Awa Tribe often use the form "*imu*."

The following are the ovens used formerly among Tuhoe: (1.) *Tuakaha* (*umu tuakaha*): A small oven: it contains food for high priests only. (2.) *Potaka* (*umu potaka*): Contains food for the priests of lower standing. (3.) *Whangai* (*umu whangai*): For the *ariki* or high chief of the tribe, the first-born of the principal family, a very *tapu* individual. The most highly *tapu* of all the ovens: even the priests could not approach it. (4.) *Ruahine* (*umu ruahine*): Contained food for the *ruahine* only, an elderly woman who was employed in *whakanoa*, or *tapu*-lifting rites. (5.) *Pera* (*umu pera*): Contained food for the warriors, fighting-men who had been proved in battle, and termed "*toa*," "*arero-whero*," "*ika-a-whiro*." This was a large oven, 10 ft. to 20 ft. in diameter. No women were allowed near it. (6.) *Tukupara* (*umu tukupara*): This was a very large oven (or ovens) in which was cooked food for the ordinary people—*i.e.*, the bulk of the people.

A portion of the sacred food was eaten by the priests, and a portion, as we have seen, was offered to the dead. People had to be very careful in regard to the above-mentioned ovens and the foods they contained. They were *tapu*, and all rights pertaining thereto were jealously guarded. The last-mentioned (No. 6) alone might be approached or partaken of by any person. Should a person approach the oven (or its contents) of the priests or *ariki* (*matamua*), there was trouble toward of a very serious nature. But to take of such a food and eat it, even the scraps from a meal, was an act of impiety dreadful to think of. If a common person, the offender might be slain, or he might die of fright if the act had been done in ignorance. Anyhow, it would need a priestly rite to save him from the anger of the gods. If eaten in ignorance, and a priest were called in, the latter would perform the diagnostic rite in order to ascertain the cause of the patient's illness. He would then say, "*He popoa to mate.*

Nau i kai i te popoa." ("Your complaint is caused by your having eaten of the *popoa*"). This "*popoa*" is a term applied to the sacred foods set apart for the *tapu* persons who take part in the disentombing ceremony. For another person to eat such food was a *hara*, and the act would affect his throat, which would contract, or seem to contain some obstruction. "*Popoki*" seems to be another name for the *popoa*—sacred food used at the *hahunga tupapaku* ceremony, as also that used at the rite to take the *tapu* off a new-born child and its mother. One authority, and a good one, says, "*Mo tenei ingoa, mo te popoki ko te mea tuatahi i te haerenga ki te mahi kai mo te tuatanga—manu ranei, ika ranei, ka kawea ki mua ma te atua*" ("In regard to this word '*popoki*,' it is the first article of food obtained by a party who are collecting food for the *tua* rite over a child, be it bird or fish; it is taken to the sacred place and offered to the god").

But we must lift the *tapu* from the sacred foods of the *hahunga* feast or black death will be our portion. The *tapu* is removed by means of a *karakia* (invocation, charm, &c.) called a "*whakau.*" This is recited by the priest, who takes a small portion of the food (as a single sweet-potato) and offers it to the ancestral gods, to give power, influence, to his invocation. He then takes a small portion of the food and holds it over the bulk of the foods to be freed from *tapu*, and repeats,—

To kai ihi, to kai ihi
To kai Rangi, to kai Papa
To kai tapu
To kai rua Koiwi
To kai awe
To kai karu
To kai ure pahore
To kai matamua
To kai rua tupapaku
Whakataha ra koe
E te anewa o te rangi e tu nei
He tawhito to tapu e homai nei
Kei taku ure
Na te tapu ihi, na te tapu mana
Hinga ki mua
Takoto ki raro
Ki to Kauwhau ariki.

The priest then lifts the piece of food to his mouth and recites,—

E kai tatau, E kai! E kai!
Kai atu tatau ki nga ihi i te rangi
Kai atu tatau ki nga tapu i te rangi
Kai atu tatau ki nga ruanuku
Kai atu tatau ki nga rua Koiwi
Kai atu tatau ki nga rua tupapaku

Kai atu tatau ki nga atua tapu
Kai atu tatau ki nga mana i te rangi
Mate rouroua tiritiria, makamaka
Kia kai mai te ati tipua
Kia kai mai te ati tawhito
E kai! E kai!
E horo, e horo o tatau kaki
Kia kai nuku tatau
Kia kai rangi tatau
Kia kai matamua tatau
Kia kai wahi tapu tatau.

Thus is the *tapu* taken off foods and persons, and the assembled peoples may then eat. Should they eat of the food before the *tapu* is lifted from it, then such food would turn upon and destroy them—which means that the gods would destroy or afflict them sorely for having been guilty of a *hara*, or infringement of *tapu*. The *whakau* also lifts the excess of *tapu* from sacred persons, such as priests and *ariki*. Understand, the *whakau* is the highest order of such invocations, but it is only repeated over the most highly *tapu* food, as the above-described, or food which has been carried on the sacred back of a *matamua* (first-born of a high chief's family). The *taumaha* is another variety of such *karakia*, but it is recited over ordinary foods much less *tapu* than the above. This *taumaha* also removes the *tapu* from foods. The *whangai* is a kind of *whakau*. It is applied to food "fed" (*whangaia*) or offered to a god (*atua*), and over which a charm is repeated by the priest. If persons are going on a journey to places where they fancy they may be bewitched, they cook some food, over which the priest recites his charm. A portion of this food the travellers eat, and a portion of it they thrust into their belts and so carry with them. It will have the effect of warding off the shafts of black magic. When they return from their journey, and before they enter the village, the priest will take the *tapu* from them, or it might endanger their welfare, or even their lives. They are then free to go to their own homes. The *whakau* is nowadays often termed a "*whakawhetai*," a very misleading expression.

A good authority informs me that, should a person in former days so forget himself as to eat of the *umu whangai* (No. 3), he would at once be slain.

In ancient times the flesh of the breed of native dogs known as *ruarangi* was much esteemed for these funeral feasts of the Maori.

A good deal of the above ritual is still retained at these functions among the Tuhoe Tribe.

Among the Ngati-Awa Tribe the following appears to be a list of the ovens used at the *hahunga*: (1.) *Umu kaha*: For the priest. (2.) *Umu potaka*, or *umu kirihau*, or *imu tamaahu*:

For *matamua* (see *ante*). (3.) *Umu waharoa:* For the bulk of the people.

The *imu pararahi* seems to be the same as No. 1. But my notes on Ngati-Awa rites are very meagre. Tutakangahau, of Tuhoe, says that the *pararahi* was an *umu marae—i.e.*, for the bulk of the people. A Ngati-Awa member states that among that people women were not allowed to partake of the *pure* foods.

Caves and holes, chasms, &c., where bones of the dead are deposited are called "*whara.*" They are usually situated in very secluded spots, and are often most difficult of access. Some of these caves, situated in precipitous cliffs, have to be approached by ladders, or by a person being lowered from the summit of the cliff. One at Rua-tahuna can only be gained by climbing a tree, then laying poles from the tree-top to the ledge of the cliff-face where the cave is. Some, with small entrances, are blocked by means of stones. Some, again, are mere rock shelters, not true caves.

As the bearers of the bones of the dead proceeded to the cave or tree where the bones were to be deposited, a priest preceded them repeating the following (*E haere atu ana ano, ka timata te karakia waere atu a te tohunga*) :—

He kimihanga
He rangahautanga
Ka kimi ki hea ?
Ka kimi ki uta
Ka kimi ki hea ?
Ka kimi ki tai
Ka kimi ki te Po
Ka waere ma kereta
Ka waere ma kereti
Ka kitea mai te hau o te tipua
Te hau o te tawhito mai te rangi tu
Kai te kahui mate i te Po
Kai te kahui ora i te ao nei
Tena ka kitea koe ki tua
Ka kitea koe ki te whai ao
Ki te ao marama.

The bones of each person are made into a bundle, and are, or were, often smeared with red ochre (*kokowai*) before being placed in the cave. The party who carry the bones to the *whara* have to be *whakanoatia*, or freed from tapu, before returning home.

Among the Maori people, the elements of fire and water were the recognised purifiers of persons, objects, and places which were *tapu* (sacred, or unclean). Oriental peoples utilised them for the same purpose. In ancient Rome, on the return of relatives of the dead from the cremation of the corpse and the placing of the remains in the sepulchre, they "stepped over a fire and were sprinkled with water."* Among the followers of Zoroaster water is the great purifier, but the urine of cows is also used for that purpose, and also as a charm against evil spirits.† A similar custom to the latter obtained among the Maori, as we will endeavour to show in the days that lie before.

A Native woman died recently at Ruatoki. She was, as is usual, placed in a tent to die, hence the cottage of herself and husband did not become *tapu*. They had another, a rude hut built of trunks of fern-trees, some distance away, where they lived when working in their maize-field, and in which they kept various cooking-utensils. Riding past the spot this day, I noted that the hut had been burned, with its contents.

Ahi mate (extinguished fire): This term is applied to a place where all the people have died, or are ill, and so cannot keep their fires going, as a place where an epidemic is raging. It is often used as is the "cold hearthstone" of Keltic peoples.

Whare ngaro, or *whare mate*: This expression implies a lost house—*i.e.*, a lost line of descent, where all members of a family die without issue.

Marua matenga rangatira: The word "*marua*" is used to denote a land deprived of its protector, safeguard, counsellor, &c.; as when a head chief dies it is remarked, "*Marua ana te whenua*" (*ara, kua kore he tino tangata hai arai i te kino, i te aha, i te aha, i te aha*).

When a Maori dies his children inherit his property. Weapons, implements, &c., of ordinary kinds would be shared, or all would use them, also clothing. But any specially prized or valuable weapon or garment (*e.g.*, a dogskin cloak) would become the property of the eldest son, who would have the arranging of such matters. Such an article as a canoe would be used by all the children—*He waka eke noa* (any one can use it).

When Kahu-tatara was slain by Ruru at Pu-kareao the relatives of the dead man felled the trees at the spot where he was killed, as a *tohu* (sign, or memorial) for his death. When Te Ahuru, of Tuhoe, died at Rua-toki he was buried at Te Tawhero *pa* (fort). A dog burrowed his way into the grave. It was seen, pursued, and killed in crossing the Whakatane River. Hence that river was *tapu* for some time, the *tapu* being finally removed by Kereru te Rua-kari-ata, who drank some of the water during the ceremony.

Among Tuhoe, most ghoulish of cannibals, the body of a

* "Anthropological Religion," p. 272.
† "The Story of Religions," by E. D. Price, p. 46.

person who died a natural death was sometimes eaten, if he was not a near relative.

When a loved relative, as a favourite child, dies it is a common thing for the child's property, clothing, playthings, &c., to be destroyed or given away. In the case of Marewa, cited above, this was done so completely that no article of hers remained, whereupon her grandfather applied to the master of the Native school that she attended for the child's slate, that her people might have something of hers to greet over and remember her by.

On the death of a chief of importance, one possessed of much *mana* (influence, prestige, &c.), social, intellectual, and spiritual—a person who would, of course, be highly *tapu*—a peculiar rite was performed in many cases by the eldest son of the deceased, in order that he might acquire the powers of his father. A part of this ceremony consisted in the son biting the ear, or big toe, of the corpse.

When Mahia, of Tuhoe, was slain by Te Whakatohea at Te Pa-puni those lands were made *tapu*, on account of a chief's blood having been shed thereon. This of course meant that no one might utilise the food-products of such lands. Some of the people living there did, however, eat of such foods. This being a serious violation of *tapu*, a party of Tuhoe marched on the Pa-puni and slew many of those erring ones.

When Ngati-Awa defeated Tuhoe at O-tu-kai-marama, near Te Teko, they captured alive both Wahawaha and Tipoka of the latter tribe. Before being slain the captives sang together a song of greeting, affection, and farewell to their tribe and lands. They were then slain by the widows of those of Ngati-Awa who had been slain by Tuhoe.

The Ngai-Tama clan of Te Whakatohea Tribe assisted in defeating Ngapuhi at Motiti Isle. They were under the chief Titoko, who brought to Opotiki a cannon which had been captured from Ngapuhi. This cannon was fired off whenever a chief died, for the Maori delights in making a noise at such times. A Native who had his horse drowned while crossing the creek near my camp at Rua-tahuna returned with his gun and fired several shots over the place where the animal perished.

Plumes of the *huia* and *kotuku* birds were used to decorate the heads of deceased chiefs as they lay upon the *atamira*. The Ngati-Awa people say that fine plumes of the *moa* were formerly used for this purpose. They were termed the "*rau-o-piopio*," and grew under the "armpits" of the *moa*.

When in former times a man was lost and thought to be dead, the priest would perform a certain rite and repeat a charm to cause the bones of the dead to "resound," so as to make known their whereabouts. The bones of a murdered man were collected by a priest, who placed them in a heap before him. He would then proceed to *whakatara* the same—that is, to recite an incantation over them to cause them to give a sign to show whether or not the death would be avenged. A singular kind of divination this! Should the bones move of their own accord as they lay before the priest, that was deemed a *tohu toa*, a token of victory—the death would be avenged.

We have seen that lands were *rahuitia*, or placed under *tapu*, sometimes at the death of a chief. The same thing was done in regard to rivers, streams, and lakes. When Matiu's sons died, the Okahu Stream at Te Whaiti was put under *tapu*, as also were the Ngaputahi lands. Hence no fish, birds, or vegetable foods could be taken therefrom until the *tapu* was lifted.

In the case of an important chief or priest his *tapu* would be intense. At his death his son, or whoever prepared him for burial, would have to be extremely careful in his speech and actions. Any error made would cause his death—*e.g.*, a mistake made in repeating a charm or invocation. Persons so deeply *tapu* could not touch food with their hands, and had to be fed by another person, or gnaw at the food on the ground, as a dog would.

A special person, termed a *takuahi*, was often employed by priests to kindle sacred fires and ovens for them.

For the bones of their dead to fall into the hands of enemies was a dreadful thing to the Maori, for that enemy would heap every indignity on such. Drinking-vessels were formed from skulls. In one such case in this district a man obtained an enemy's skull and grew in it a *taro* as food for his child.

Infringements of *tapu* were sometimes punished by a party of the tribe, often of near relatives of the transgressors, coming and forcibly seizing and carrying away the portable property of the latter, as food, &c.

When old Hakopa, of Te Umu-roa, died, which was on the 14th November, 1900, we did not hear of the death at my camp until the next day. But on the afternoon of the 14th my near neighbours, an old Maori couple, living 200 yards from my camp, came to my tent and asked me what I had called out for. On my replying that I had not called them they retired. Next day they came up and said, " We have just heard that Hakopa has died. Now, it was his *wairua* (spirit) that we heard calling out yesterday, and thought that it was you calling. Spirits of those recently dead often do these things." When Natives are annoyed by such a spirit of the dead they proceed to banish it by cooking a potato, carrying it round the hut, and then eating it. Even the smoking of a pipe may have the desired effect.

We have noted that a large proportion of deaths were, in former times, ascribed to the gods, who thus punished the violation of *tapu*. Even those who were said to perish through witchcraft may come under this heading, for the gods imparted the power to such magic spells or charms. But many different causes were given in those days. Here is an example: When discoursing on the history, &c., of the tribe, should a person of the party condemn some statement made as being false, in order to make himself appear important, "two nights," as my informant put it, "would not pass ere he died. For our ancestors would hear their tribal history condemned, and would slay the person who denied its truth. Such is the power of our ancient knowledge. Thus do our ancestors watch over and guard us."

Death was not often allowed to interfere with important tribal duties. After Whitmore's raid on Rua-tahuna, Tuhoe gathered at Tahuaroa and decided to send Himiona te Pikikotuku to Roto-rua to sue for peace. He said, "How can I go? My wife is dying." His wife at once said, "Do not think of me. Think only of the tribe." So Himiona started for Roto-rua. As he was ascending the range above Pu-kareao he heard across the forest-clad hills the volleys which told him that his wife had passed away. But he trudged on, bearing the greenstone battle-axe "Hau-kapua" as a peace offering to the Government.

An old woman of the Ngati-Manawa Tribe, being near death, caused her people to place her on a sledge and drag her to the base of the range, near Horomanga Creek, dig her grave there and place her in it, where she died. She had told them before as to the day she would die.

When Mawake, of Kawerau, died his bones were placed at Waitaha-nui. Manaia found them and took the jaw-bone, from which he fashioned a fish-hook. When he went a-fishing with this hook all so gay a sign came to him: a fish called "*aho*" leaped into his canoe. Then the monsters of the deep rose and destroyed Manaia and his fellow-fishermen. Moral: Don't interfere with *tapu* objects.

The expression "*mate a rakau*" is sometimes applied to a natural death. It implies decay, or death as a tree dies—of decay, not by violence or magic spells. The terms "*mate tara whare*" (death by the house-wall) and "*mate koeo*" (also termed "*mate aitu*" and "*hemo o aitu*") are also used to denote a natural death. "*A, roa kau iho ano i muringa iho o taua taua nei, ka mate a Nahu. He tino koroheke a ia, a mate a rakau ai tona mate, ara i tae ano ki te wa e ruhi ai te tinana, a ka mate a ia.*" ("Nahu died some time after that war expedition. He was a very old man, and his death was that of a tree—that is to say, he had arrived at the age when the body becomes very weak, and he then died.")

When Whitmore's column were marching on Rua-tahuna they attacked the Harema *pa* at Te Whaiti, slaying some of the inhabitants. Hence the place became *tapu*—not only the fort, but also the surrounding lands—on account of the blood shed there. Shortly afterwards some of the Ngati-Hine-kura clan settled on those lands, but were turned off by Ngati-Tawhaki because the *tapu* was still new. "*Kaore e tika kia noho he tangata ki kona, engari kia mataotao nga mate*" ("It was not right that people should live there until the deaths 'cooled.' ").

Besides natural decay the Maori recognised three modes of death — *mate atua*, or death caused by the gods (deaths by witchcraft (*makutu*) may also be placed under the above heading, for reasons already quoted); *mate taua*, or death on the battle-field, is a third class; while accidental deaths and suicide may be called a fourth.

Many curious notes pertaining to death may be found in my Tuhoe notes included in the late Dr. Goldie's paper on "Maori Medical Lore," in the "Transactions of the New Zealand Institute," vol. xxxvii, as also in vol. xiv of the "Journal of the Polynesian Society."

"*Nga taru o Tura*" (the weeds of Tura) is a term applied to grey hairs (of *genus homo*). The singular story of Tura and the coming of death may be found in vol. ii of White's "Ancient History of the Maori." I have never obtained any version of this peculiar legend from the Tuhoe Tribe. As also the *wai ora a Tane* (the life- or health-giving waters of Tane) I leave for other pens to describe, my Tuhoean notes on the subject being meagre. Suffice it to say that the moon bathes in those waters of life each month, and so renews her life. Maui desired that man should do the same. Tane, the ubiquitous, appears under many names, as parent, origin, or tutelary deity, &c., of trees, birds, &c. Some Natives speak of Tane-te-wai-ora being a separate person, but it seems probable that there was but one Tane, who, however, assumed many functions under different names, like unto the god Merodach, of Babylonia.

Under the term "*ahi parapara*" we find some very curious rites and charms or invocations. The expression "*parapara*" is applied to many things—as remnants of clothing of the dead, the spittle of a living person, &c.—but always, I believe, bearing or implying the sense or state of *tapu*. Two of these rites were known as "*ahi tute*" and "*ahi rokia*." They were utilised to *whakanoa*, or make common (to remove *tapu*, to purify), as, for instance, persons who had become *tapu* through touching or handling something belonging to the dead. Observe the terms "*ahi tute*," or *tute* fire, "*ahi rokia*," or *rokia* fire: these expressions are really equivalent to "the *tute* rite" and "the *rokia* rite." But in the performance of these rites sacred fires were kindled by the priest—kindled by the friction process, hence they were styled "*ahi pahikahika*," or generated fires, for such sacred fires must be so generated by means of the ancient and primitive process of the Maori; they could not be kindled by means of a firebrand or coals from another fire, and to light them by such means from a cooking-fire would spell death for every person concerned. But note how the idea of the purifying effect of fire has been retained in all these Old-World customs and ceremonies.

The word "*tute*" implies a driving or thrusting away. The following incantation is to thrust away or fend off the hurtful powers of *tapu*, *mana*, and *parapara*—*i.e.*, to make common and render harmless.

The Tute Charm. (Part only.)

I ka ra taku ahi tute
Tute hoki tua, tute
Tute hoki waho, tute
Tute ka mania, tute
Tute ka paheke, tute
Tute ka whati, tute
Tute ka oma, tute
Tute nga tapu nei, tute
Tute nga mana nei, tute
Tute nga parapara nei, tute.

This was all that my informant could remember of this peculiarly worded *karakia*.

Here follows the *rokia* charm or incantation. The expression "*rokia*" or "*roki*" implies a lulling of the senses, a causing of forgetfulness, a dulling of visual and mental perception. *Cf.* the terms "*rotu*," "*roku*," and "*roroku*." The *rotu* is a charm to put a person to sleep.

The Rokia Charm.

Hika ra taku ahi e roki
Rokia i nga parapara nei
Rokia i nga tapu nei
Rokia i nga mana nei
Kia tae koe
Koi ihi, koi nana
Koi naunau (ngaungau) e roki.
Ngoru—he.

"This ceremony is an *ahi parapara*. The *rokia* renders the *parapara*, *tapu*, &c., harmless—prevents them from turning to afflict man."

A singular expression, overheard by myself one day: "The stones with which the body of Te Whatu-pe was cooked are still weeping." As usual I made inquiries, for you must be keen to catch and follow up such remarks if you wish to acquire the old-time lore and study the mentality of primitive man. Te Whatu-pe, of Tuhoe, was slain by a party of Te Whaka-tohea about five generations ago. His body they cooked in a *hangi* (steam-oven) and ate. It is said that the stones used to heat the oven are still weeping—that is to say, the fat from the cooked body is still exuding from those stones, but only when the descendants of Te Whatu-pe visit the place.

"*Peka titoki*": An expression often heard when persons are speaking of death. The branch of a *titoki* tree (or, presumably, of any other tree) dies, decays, and is seen no more, but the *peka tangata* (human branch) decays and is seen again in his offspring. So-and-so is dead, but his children survive—*apa he peka titoki* (if he were a *peka titoki*, then indeed he would leave no trace behind). The rendering given by Sir George Grey in his "Maori Proverbs" is different. The term "*peka titoki*," he says, is applied to anything difficult to break, or to a people difficult to conquer. The *titoki* has a very tough, strong timber, resembling hickory.

The Maori was a believer in metempsychosis. When Hine-ruarangi, daughter of Toi the Wood-eater, of immortal fame, died, her spirit entered upon another earthly life in the form of a cormorant, which bird has since been the tribal banshee of the Ngati-Whare Tribe, of Te Whaiti. Whenever a chief of that people is about to die, or prior to a defeat of the tribe in battle, the bird appears flying above the village of Ngati-Whare at Te Whaiti. Another of their omens of a like nature is the playing of lightning on the mountain-peak of Tuwatawata. Each tribe of this district has its *rua koha*—principally high ranges or peaks, to see lightning playing on which is believed to foretell the death of a tribal chief. Landslips are also looked upon in a similar manner.

Te Tahi and Te Putaanga, two ancestors of the Ngati-Awa Tribe, are said to have both reappeared as sea-demons (*marakihau*) after their death. They are represented among the carved ancestral figures in the Native meeting-house at Ruatahuna.

Spirits of the dead are said to sometimes return here in the form of butterflies or moths.* The spirit of a stillborn child may enter a bird, or fish, or animal, or insect, when it works havoc as a caco-demon.

Nga-rangihangu, an ancestor of the Ngati-Manawa Tribe, became a *taniwha* (water-demon) after death, and abode in the Rangi-taiki River at Raepohatu, near Te Houhi.

* *Cf.* beliefs of the Samoans and Niassans.

Expressions, Proverbs, Aphorisms, etc., pertaining to Decay and Death.

"*Nga mate i Kawerau, me tangi mai i Whakatane; nga mate i Whakatane, me tangi atu i Kawerau*" (The deaths at Kawerau, mourn for them from Whakatane; those who die at Whakatane, mourn for them from Kawerau). This saying is applied when persons are too busy or are disinclined to attend funeral obsequies at a distant place.

"*Ka mate he tete kura, ka ora he tete kura*" (When a chief dies another is ready to take his place).

"*Wairoa tapoko rau*" (Wairoa engulfs hundreds). Applied to the Wairoa district, Hawke's Bay, on account of so many people being slain there—by witchcraft, according to surrounding tribes.

"*Tauarai o te Po, titoko o te ao marama*" (Screen from Hades, prolonger of life). Applied to those who succour persons in danger.

"*Mohaka whanaunga kore*" (Mohaka the relationless). Applied to the Mohaka River, on account of so many persons having been drowned therein.

"*Ka pu te ruha, ka hao te rangatahi*" (The old net is laid aside, the new net takes up the work). When men become old, feeble, and near to death, young men take up their work.

"*Puritia to kauri hai o matenga mou*" (Keep your *kauri* as food for your death journey). *Kauri* = the soot from resinous wood, used for tattooing-pigment. This remark is said to a mean person who will not give something he has been asked for.

"*Whatu ngarongaro he tangata, toitu he whenua*" (Man passes away, but the land remains for ever).

"*Kua tau nga Taru o Tura*" (The weeds of Tura—grey hairs—have appeared, death is approaching).

"*Kati te tangi, apopo tatau ka tangi ano, apa ko te tangi i te tai, e tangi roa, e ngunguru tonu*" (Cease wailing, to-morrow we shall mourn again. We are not like the sea, which ever murmurs, ever rumbles). Said at funeral obsequies when the crying and wailing is prolonged.

"*Matua pou whare, rokohia ana; matua tangata, e kore e rokohia*" (You can always seek and gain shelter in your house, but not always so with a friend—death may take him).

"*Kei mate a tarakihi koe*" (Be careful lest you perish, or suffer, through indolence, dilatoriness, &c.).

"*Engari kia mate a ururoa te tangata*" (Rather let man die as does the *ururoa* shark, strenuous and fighting to the last).

"*Na wai te kokomuka-tu-tara-whare i kiia kia haere?*" (Who said that the house-wall-growing *Veronica* should travel?).

Used by an old person, feeble from old age, when asked to leave home. He sticks to the house or house-wall, like the species of *Veronica* called "*kokomuka-tu-tara-whare*," which grows on the earth-covered sleeping-houses.

"*Kai hea te ua o te rangi hei ua iho i te rae o Tane-nui-a-rangi*" (How may the rains of the heavens fall from the brow of Tane-nui-a-rangi). Quoted by a person who saves another from death in battle, especially when his power to do so is questioned.

"*He iti na Tuhoe e kata te Po*" (A few of Tuhoe and Hades shall laugh). A saying applied to the Tuhoe Tribe, on account of their valour and ferocity in war.

"*Ka pa te hau mihi kainga, he hurihanga kaupapa*" (When soft, gentle breezes blow, then disaster is nigh). Such winds are deemed an omen of death or disaster.

"*Ehara i te ti e wana ake*" (When man dies he is seen no more, unlike the *Cordyline*, which when cut down sends forth shoots from its stump).

"*He ai atu ta te tangata, he huna mai ta Hine-nui-te-Po*" (Man begets offspring, while the Goddess of Death destroys them).

"*Ka mate tino tangata, tena e rewa mai*" (When a chief dies plenty of *uhunga* or mourning parties will come).

"*He wahine, he whenua, e ngaro ai te tangata*" (Through women and land do men perish). These were prolific causes of war.

"*He toa taua, mate taua; he toa piki pari, mate pari, he toa ngaki kai, ma te huhu tena*" (The warrior dies on the battlefield, the cragsman by cliff-side, but the industrious cultivator perishes of natural decay).

"*I paia koia te Reinga?*" (Is the underworld closed?) Be not foolhardy or you will perish.

The term "*aroarowhaki*" denotes the quivering of the hands, with arms extended, as seen performed by mourners, usually by elderly women.

When Big Jim, the guide, of Taranaki, was killed at Manawahiwi, just where the road from Te Whaiti commences to ascend Tara-pounamu, by an ambush of Tuhoe, the force camped at that place for the night. Major Scannell informs me that the force buried the body of the scout, and lighted a large fire on the grave that it might not be noticed by the enemy when the party moved on.

When the famous Winiata, of the Native Contingent, was slain at Taupo his body was buried in the bed of a stream for a similar reason.

In H. B. Sterndale's writings we find a description of exhumation as practised in the Caroline Islands, where the bones were cleaned, painted, and preserved, as among the Maori.

A singular rite, the invoking of the dead, the spirits of dead-and-gone ancestors, that they may aid their living descendants in battle. See a description in the " Journal of the Polynesian Society," vol. viii, p. 217.

In regard to the *popoa*, or sacred food, above mentioned, we see in Mr. Percy Smith's account of Niue and its people that the word "*poa*" there means "an offering to the gods." This is evidently the original meaning of "*popoa*."

In the " Journal of the Polynesian Society," vol. vii, p. 50, is a note from Mr. R. E. M. Campbell, in which he mentions the grave near Kihikihi, Waikato, wherein " the bodies were buried in a circle, the feet toward the centre." In the same Journal, vol. xii, p. 209, Mr. Percy Smith has a note on the custom of sacrificing slaves at the building of a fort (*pa*). " In the case of a *pa*, slaves were often buried in a sitting posture, embracing the base of the main posts of the palisading. Not many years since six skeletons were discovered in such position at the base of the posts of a large *pa* near O-potiki."

We have seen that the spirits of the dead sometimes afflict the living. Such complaints are termed "*mate kikokiko*," and are said to frequently result in death. An old man explained to me, " The spirits of dead persons are afflicting such sufferers. These *kehua* control them. If the afflicted person survives, he will be the medium of that [evil] spirit. Some people become demented when so affected." Natives say that these spirits of the dead are sometimes seen as a flying luminous object at night. They move swiftly, but never far above the earth. The name "*tirama-roa*" is applied to this phenomena. "*Tirama-roa* is a (spirit, a ghost) *kehua*, a *whakahaehae*, a *turehu*. It is not a star-name. It looks like a moving torch, and is seen moving along the tops of high ranges. It is a spirit of the dead. I have seen such at Maunga-pohatu, flitting along the range-top. *Tunui-a-te-ika* is a *kehua*. It has a big head, and flies through space. It is a sign of death."

When the Okarea *pa* (fort) at Wai-a-tiu fell to Ngati-Awa and Tuhoe, the chiefs Te Hauwai and Taha-wai were slain, their bodies falling over the cliff into the Wai-a-tiu Stream, a tributary of the Whirinaki River. Hence this river was long under *tapu*. In after-years it was Puritia who lifted the *tapu* and sacrificed a slave named Tamure in order to give force to the rite.

The old custom of *muru* is rapidly passing away, but in former times it was strictly carried out. It was applied in many ways. For example, should a person meet with some accident or other trouble, a party of the tribe would proceed to despoil him and his family of their portable personal property. This was also done sometimes at the death of a person; his family would thus lose their food, &c., which would be seized and taken by the plundering party, who often acted in a very rough manner. Colonel Gudgeon attributes this peculiar custom to the communistic mode of life of the Maori. A man's life, energies, knowledge, &c., were tribal property primarily, and his relatives had no right to let him die or be injured.

Suicide.

Te Mauniko, wife of Te Ahuru, shot herself when their son Kawana died.

Mautini committed suicide by jumping into a pool of boiling water at Tikitere, because her husband had deserted her. She could not stand the jeers of the people.

Ridicule was a frequent cause of suicide among the Maori.

No difference was made as to the burial of suicides.

The Maori Hades. (Maori Ideas concerning the Spirit-world.)

No paper on Maori eschatology would be worth notice unless it contained some explanation of the Native conception of the spirit, or soul, of man, as well as their ideas concerning the spirit-world. Hence some description of these matters here follows. Lest, however, their briefness cause comment, I may state that they are purposely curtailed, and for two reasons. In the first place, I have already published many notes on these subjects in my paper on "Spiritual Concepts of the Maori," and also I propose to leave other matter, not yet published, for a paper on "Maori Religion," should I ever be able to summon courage to attempt to describe such an intricate system. Moreover, methinks this paper is already quite long enough to try the patience of the hapless reader.

As observed, I have already attempted to record the Maori conception of the spiritual nature of man. This has been approached with no preconceived ideas of primitive religions, nor yet with any fanatical leaning towards any religion, primitive or otherwise. I have no pet theory to bolster up, nor do I wish to identify the Maori with the Lost Tribes. I would much rather they remain lost. The world can well spare them. Hence I hope to compile a truthful, if meagre, account of Maori beliefs.

The *wairua*, or spirit, of man was, according to Maori belief, equivalent to the *ka* of the ancient Egyptians, the shadowy self which leaves its physical basis (as in dreams) and wanders afar off. But the *ka* continued to abide in the body after death, whereas the Maori *wairua* leaves the body at death and descends to Hades, the underworld, "Te Po," as the Maori terms it. *Po* signifies night; *po uri* = darkness; hence, apparently, "the realm of darkness," or oblivion; although other evidence seems to support the idea that the underworld is by no means a realm of darkness, and that the dead lead there a life very much like life in the upper world. This world and this life are termed the "*ao marama*" (world of light), as opposed to the *po*, or world of death.

The Maori had neither evolved nor borrowed a belief in a soul, or *psyche*, which is judged after death and punished or rewarded as for evil or good deeds committed in this world. No such distinction exists in the Maori spirit-world. The old-time Maori looked forward to no condition of calm peace and happiness in the next world, nor to any sensual pleasures. On the other hand, however, he was not terrorised by threats of raging hell-fires waiting for him, as are we.

The Maori was ever a firm believer in and practiser of necrolatry, pschomancy, physiolatry, and oneirology.

If when a person's *wairua* is absent from the body it comes under the effect of spells of black magic it is destroyed, and its physical basis, the body, also perishes. But during such rambles it often discovers some danger threatening the body, and returns to warn it. On awaking from sleep a man might say, "So-and-so is trying to bewitch me, my *wairua* has warned me."

A Maori dislikes to awake a person suddenly, as by shaking him. His *wairua* may be absent on a little jaunt: it is well to give it time to re-enter the body.

Maori religion is essentially polytheistic — very much so. And yet we see, in some very ancient and fragmentary tokens of a former cult, evidence that at some remote period in the history of the race either monotheism or something akin to it must have prevailed. I refer to the cult of Io.

Animistic conceptions teem in Maori myth—they form its most notable feature; and a very interesting monograph might be compiled on this subject. The *anima mundi* theory is quite Maori.

The *wairua* (spirit) of man is an intelligent, a sentient spirit. It leaves the body at death, and either descends at once to the underworld, or remains near its physical basis as a *kehua*, or spirit-ghost. These ghosts are much feared by the Natives, for they can inflict grievous injuries on the living.

Nearly all Maori gods may be termed ancestral, though I have never heard the term applied to Io—he who formed or was the origin or prototype of all other gods. Unless Io comes under that heading, moral gods are lacking in the Maori pantheon. Rongo and others were gods of peace, but their code of ethics was scarcely pure.

An ancestral god would succour and protect his descendants, unless they violated some law of *tapu*, when they punished the erring one with severity. But they were powers for evil: they imparted the power to the spells and rites of black magic practised by their descendants. They were also war-gods of great ferocity and of a pitiless nature.

Spirits of the dead were termed "*kehua*," or "*whakahaehae*" (spirit-ghosts), or "*kikokiko*" (man-assailing evil spirit), or "*atua*" (demon); sometimes merely "*wairua*," a term applied to the spirit of man, whether its physical basis be living or dead. The Maori has not the elaborate system of spirit nomenclature possessed by the old-time Romans, with their "*lar*," "*lemur*," "*larva*," "*manes*," and "*penates*."

It has been stated that the spirits or souls of the chiefs of the Maori are believed to ascend to heaven at death. This is not an old-time belief among any Maori people I wot of, but is doubtless a modern idea, the result of missionary teachings. In the words of an old Native of Ngati-Awa: "Our ancestors never said that the spirits of the dead ascended to the heavens. Our parent Rangi [the Sky] never said 'Let my descendants ascend to me.' But Rangi said unto Papa [the Earth Mother], 'Our descendants—treat them kindly, conceal them in many places —beyond, seaward, inland, in the realm of darkness.' Friend, there were two men of my people, Ngati-Awa, who died. Their spirits descended to the *reinga* (spirit-land). Their parents sent them back to this world. They said that when they arrived at the *rerenga-wairua* they stood on the beach by the waterside until the waters receded and exposed a hole in the rocks. By this way they descended to the underworld. They came to a fence which was guarded by several persons, who told them not to pass under the fence, but to clamber over it. They did so, and went on. They saw great numbers of people, but they were all spirits. They at last came to their relatives and parents, and all wept together for some time, after which they were returned to this world of life. I have told you this to show you that spirits of the dead do not ascend to the heavens. The names of those two persons were Kukia and Toihau. They said that the spirit-world is a very good sort of place, and not shrouded in darkness, but light like unto this world. The spirit-world is divided into ten different divisions, according to the teachings of our ancestors. The spirits of the dead abide in the tenth division (*Ko te ao tuangahuru te ao nohoanga o nga wairua*)."

"Now, when a Maori dies, his *wairua* (spirit, or soul) leaves and goes to the *rerenga-wairua* (spirit's leaping-place). On arriving at the resting-place on the last ridge (the *taumata i Haumu*) the spirit halts and laments, weeping, the world it is leaving. It also lacerates itself, in grief, with obsidian, of which there is much lying there. When the mourning and weeping are over, the *wairua* descends the cliff by means of the roots which are there, to the beach below. It goes on, and passes out on to the rocks. Gaping there is the hole by which the spirit descends to the *reinga*. The ocean-waters surge upwards through this chasm, the seaweeds are swirled round by the waters. Then the waters recede and leave exposed the abyss. Down into this the spirit leaps, and finds itself in the spirit-world. There the sun is shining, there is no darkness. It is just like this world. The spirit proceeds onward until it comes to the fence. Should it pass over the fence, that spirit will return to this world. But if it passes under the fence it is gone for all time, it will nevermore return to this world. When the spirit reaches those of its relatives and is offered food, should it eat of that food it will never return to this world."

Here in this narrative we see the spirit-world described as a place where no darkness prevails, a world lightened by the sun. This is the result of persons dreaming of having descended to the underworld, as in the case of the two persons quoted above. A person recovering from a trance would be said by the Maori to have returned from the spirit-world. In the case of Toihau, above quoted, another authority stated that he died, and that the spirit of an ancestor, one Te Nahu, came and led his spirit to the underworld, and also warned him that if he ate of proffered food in the spirit-world his spirit or soul would be lost for ever, and return no more to the world of life. So Toihau refused the food offered by the spirits of Hades, hence he (his spirit) was returned to this world, the *ao marama*. It was conducted back by the spirit of Te Nahu, who drove it forth from Hades with scourging. Back to this world came Toihau's spirit, and entered his body; so that, after being dead for three days, Toihau of the Children of Awa rose from the dead and lived again. This was evidently a case of trance.

The wife of Te Puke-nui was carried off by spirits, say the local Natives, and she saw the spirits of all the dead-and-gone people ere she returned here. This was evidently a case of dreaming.

Another case, quoted locally, is that of a woman who died, after which her husband married again. Then the spirit of the dead wife appeared and carried off the living wife, and had nearly succeeded in slaying her when rescued by her husband. But enough of these childish tales: they are most numerous among the Natives.

I have no notes as concerning the names of the different divisions of the *reinga*, or spirit-world. The following extract is from "Nga Moteatea," p. 419:—

> . . . I te Reinga tuarua
> Te whare i a Miru
> Ko te otinga atu o te wairua
> Kei wheau ake ki te ao.

(The second *reinga*, the abode of Miru, where for ever disappears the soul, lest it rise again to this world.)

The usual term applied to the spirit-world is "*te reinga*," literally "the leaping-place." Strictly speaking this is the name of the departing-place of spirits for the underworld, the entrance thereof. This entrance is often termed "*te rerenga wairua*" (the spirit's leaping-place). It is situated at the north-western extremity of the North Island of New Zealand. The spirits of all Natives who die in these isles are said to pass along the ranges until they reach the above place, whence they pass down to the underworld as described. It is said that Natives residing in the northern peninsula often see the spirits of the dead wending their way to the *rerenga wairua*, and that they know which are spirits of chiefs and those of common people. The spirits of chiefs always go on one side of food-stores, so as to avoid them, while those of plebeians pass underneath such stores.

Throughout Polynesia these departing-places of spirits of the dead are situated on the western or north-western side of each island or group of islands. As we have seen, the spirits of the dead are supposed to return to Hawaiki, the fatherland of the race, which lies far to the west of Polynesia. This seems to discredit the Native belief in the underworld of spirits, but still both beliefs obtain among the Maori. Probably the underworld is the most ancient of these beliefs, while the idea of the dead returning to Hawaiki is a sentimental growth of later times, since the arrival of the race in the many-isled sea.

No information can be obtained from the Maori to show any ancient belief in different realms set apart for the souls of good and evil persons when death has claimed the body. In vol. ii of the *Monthly Review* (Wellington, 1890), in an article by R. H. Gibson on "Mourning Customs," occur these words: "It is clear that the Hebrew people maintained for many centuries the belief that the abode of the dead lay beneath the surface of the earth, and beneath the bottom of the sea; that it was a land of darkness and of shade like death itself; a land of destruction and of confusion; a land of no action and of no knowledge, where existed alike the evil and the good," &c. Here we have the old-time Maori conception of the *reinga*, or *po*, a gloomy underworld. At the time spoken of in the above quotation the Hebrews do not appear to have yet evolved, or borrowed, the idea of resurrection of the dead.

The Maori idea seems to have been that the dead met and abode with their kindred in the underworld, where they lived on sweet-potatoes, fish, &c., but that there was no fighting there. It was probably the lack of any belief in the judgment of the soul, resurrection, punishment, &c., that caused the Maori to die without fear of the spirit-world, or the second life therein. However, we have now provided him with a somewhat warmer underworld. Let us hope that he will enjoy it.

The Maori does not appear to have ever had much interest in his spirit-world, hence the description of it, even though given by old men, is vague and unsatisfactory to the ethnographer. Some say that spirits pass a certain time in each of the ten divisions of the underworld, until they reach the tenth. Some spirits are said to return to this world, the upper world, in the form of moths.

The name "*mori-a-nuku*," or "*moria-nuku*," is sometimes applied to the *reinga*, or the entrance thereto :—

Me ruku ware au te reinga tupapaku
Kei whakamau kau ki Morianuku.

"The *taumata i Haumu*," says a Native friend, "is the ridge where the spirit leaves its clothing, and so descends naked to the *reinga*, jumps into the ocean, and henceforward lives as a spirit.

Rukuhia, e tama ! Nga rimu e mawe
I raro o Haumu.

"*Te rimu ki motau*" signifies the seaweed through which the spirit passes in its descent. It often appears in Native songs :—

Ka rere whakaaitu ki te reinga
Te rimu ki motau—e.

There are two other expressions applied to the entrance to the underworld, but which appear only in songs, I believe. These are "*pua reinga*" and "*tawa mutu*." I have never obtained any satisfactory explanation of these expressions from New Zealand Natives, but Mr. Percy Smith has traced them both to Rarotonga : "At the *reinga wairua* at Rarotonga, near the west end of the island, is the place where departed spirits go to join the great majority. There grows a *pua* tree, a species of *Gardenia*, and into its branches the spirits on their way to Miru climb. Those who climb on the *rara mata*, or live branches, return to life—*i.e.*, they were only in a swoon, not dead. Those who climb on the *rara mate*, or dead branches, fall off into the clutches of Miru (called there Muru), and die for ever in the clutches of Muru and Akaanga."

In regard to the *tawa mutu*, as in the case of the *pua reinga*, the explanation comes from Rarotonga. *Tawa* ("*tava*" in Rarotongan) is the gulf or abyss below the *pua* tree into which the spirits of the dead descend. "*Kua mate io [iho] ra a Kui-ono, kua aere [haere] atu ra tona vairua [wairua], ka kake i te pua; ko te rere ra i tava [tawa]*" ("When Kui-ono died his spirit left him and went and ascended the *pua*, whence it leaped into *tawa*").

Here we have the origin of these two terms, preserved in song by the Maori of New Zealand for centuries. *Tawa* is known to the Maori as the *tawa mutu*, or last chasm.

> Ka tuku tenei au ki te reinga
> Ki te tawa mutu.

The explanation given by Paitini, of Tuhoe, is the nearest one to being correct that I have obtained locally. He said, "The *tawa mutu* is connected with the *rimu ki motau* at the *reinga*. It means the end of the spirit's journey."

> Kia tuku-pototia te tinana
> Te pua reinga ki taku matua.

And from another song,—

> Heoti taku tatari ki te ope taua
> I a te rama
> Kia wawe taku iti te iria te pua reinga
> Ki taku matua
> Kai noho au i te ao
> Whakaraukotetia e te ngutu.

Again,—

> Ka rumaki au ki te pua ki te reinga.

As also,—

> E noho ana i te ao marama
> Te rumakina ai ki te pua ki te reinga
> Ki oku hoa ka wehe i rau rangi.

And lastly,—

> Peke ana au i te taingariu o Kanapanapa [*a canoe*]
> Hai kawe i a au te pua ki te reinga.

All these are extracts from local songs, laments, &c.

Another expression sometimes noted is that of "*te tatau-o-te-po*," or door of Hades—the gates of death.* One Apatari is said to be the keeper of the door or entrance to the *reinga*. Miru is said to be the ruler of the *po*, or world of darkness, the spirit-world.† It is singular that two names are given to the underworld—the *po* and the *reinga*; as also two rulers of the realm of spirits—Miru and Hine-nui-te-Po. Possibly there is some distinction between them—perhaps two spirit-worlds. We

* "Journal of the Polynesian Society," vol. vii, p. 55.
† "Journal of the Polynesian Society," vol. v, p. 116.

have seen that there are ten divisions of the *reinga*, or underworld, and in like manner there are ten different heavens.

"*Paerau*" is yet another name that is applied apparently to the spirit-world. It may be one of the divisions of the underworld, or perhaps the name of some land where the ancestors of the Maori dwelt in the days of the long-ago, and is now confused, as is Hawaiki, with the spirit-world. We have seen that "Go to Paerau!" "Go to Hawaiki!" are expressions often used towards the dead in funeral speeches.

That species of lizard known as a *kaweau* (probably the same as the *kueo*) is a creature of evil omen. Should you see fresh signs of it in your house, or on a path you are travelling over, you may prepare to start for the underworld without delay. For that reptile was sent by your dead-and-gone relatives as a sign for you to join them in the *reinga* or spirit-land.

We were camped at Te Whaiti-nui-a-Toi. Our cook, a Native woman, got up one morning and proceeded to the mess-tent to prepare breakfast. There she saw fresh signs of the dreaded *kaweau*. She was taken ill and went to Rotorua, where she was treated by various Natives, *ringa-tu* ruffians of the shamanistic type. She said, "Cease your efforts, for I am going to die. You cannot cure me." And they could not; but a white doctor could, and did, to the old lady's great amazement.

The same old lady once said to me, "I am inclined to believe that old persons who die regain their youth in the *reinga*. Because I went to the *reinga* last night [*i.e.*, she had a dream] and I saw Kiriwera [an old woman recently dead], and she appeared quite young and nice-looking."

When a Native says that he was at the *reinga* he means that he has been dreaming. An old man said to me, "I was at the *reinga* last night and saw my old friend ———, who has long been dead. I could tell from his appearance and actions that it will be a fine day to-morrow."

Again, "*Kai te reinga koe e whakarongo ake ana; na, ka whakaororua mai tetahi mea e haruru ana, a ka oho ake koe i te moe.*" ("You are at the *reinga* listening. You hear a distant noise resounding, then you wake up.")

The expression "*awhi-reinga*" means "to embrace in the spirit-world," as when a man dreams of meeting his dead wife. The term "*mariko*" or "*po-mariko*" appears to have some similar meaning, but it is not clear to me.

When a defeated war-party returned home there was a *tangihanga* on the village plaza, weeping and lamentation for the dead. After which, a party of the village people of both sexes, dressed in their oldest and most repulsive garments, would appear before the defeated warriors and perform that sort of *haka* (posture dance) known as *manawa wera* (seared heart), or *whakatea*. The performers indulge in much grimacing at the survivors, with other tokens of contempt, vexation, and indignation, on account of those slain. The following is a specimen of the words of the *haka* :—

Te kotiritiri, te kotaratara
O tai, o huki, o hope—e
Whakatitaha rawa te waha o te kupenga
Kia tairi
A-ha-ha !
Hoki mai, hoki mai—e
Kia kawea koe ki tera whenua,
Ki era tangata
Nana i ki mai
Uhi, uhi—e—e
A-ha-ha !

In regard to the Maui myths, one of which—that relating to the mythical origin of death—we have already given: There can be no doubt but that the date at which this popular hero flourished must be placed much further back than that usually allotted to him by the Maori—about thirty-five generations —that is, if there ever was such a person. Max Muller held that Maui was a personification of the sun. If so, then his contest with Hine-nui-te-Po resolves itself into a struggle for mastery between Light and Darkness, between Life and Death. The sun entered the womb of Night to obtain life eternal.

Now, observe, in a paper by Mr. Tregear on "Asiatic Gods in the Pacific,"* speaking of the ancient Egyptians, he says, "One of their gods was Moui† . . . and this Moui had also the name of Ao, which we have seen is the Maori word for 'daylight,'" &c. But turning to page 66 of the same volume we find that "*moui*" is a Polynesian word (Niue dialect) meaning "life, living," and evidently connected with New Zealand "*mauri*" and "*mouri*" = "seat of life." In volume ii of the same journal, page 77, we see that Taranga, parent of Maui among New Zealand Natives, is in the Hawaiian isles the name of Paradise, or Eden, home of the first parents. Hence "Maui" may be, or originally have been, a synonym for or personification of life or eternal life, which strove with the personification of death (Hine-nui-te-Po) for mastery.

In the Rarotongan genealogy given at page 48, "Journal of Polynesian Society," volume viii, we see Maui given a place seventy-two generations back from the present time.

In some Polynesian myths Maui is said to have married

* "Journal of the Polynesian Society," vol. ii, pp. 139–140.
† The letters "*o*" and "*u*" are interchangeable in the Polynesian dialects, as *mau* = *mou* and *pou* = *pau*.

Hina, the Moon Goddess; in others Hina was his sister. Maui's full name was Mauitikitiki. In Tahitian folk-lore Hina marries Ti'i (Maori "Tiki") the first man, who ruthlessly slew people, while Hina resuscitated them.*

It appears highly probable that the story of Maui is a very ancient myth of a contest between Life and Death, evolved by a primitive people in times long past away; that it has been moved down the changing centuries by oral tradition, and the hero thereof localised in many lands.

We have seen that the world of death is termed the *po*. This expression is also applied to the period when the universe was in a state of chaos and darkness, before the appearance of man. In lengthy genealogies of an anthropogenic nature we observe more or less names which are said by the Natives to belong to the *po*, or period before man appeared, after which came the names of human beings. For instance, Tiki was of the *po*, not a person of this world. He married Ea, who was the first woman of the *ao marama*, or world of light—*i.e.*, of this world. They had Kurawaka, who married Tane and so produced the *genus homo*.

It is said that residents of the northern extremity of New Zealand often see the spirits of the dead passing northwards on their way to the *rerenga wairua*, or departing-place of spirits. They recognise the spirits of persons who were slain in battle by their being covered with bloodstains. Also that houses in those parts are built facing east or west, so that spirits wending their way northwards will not enter by the door.

In regard to the name of Ea: This is the name of the king of the underworld in Babylonian mythology. His son was Merodach, who, with the goddess Aruru, was the creator of all existing things. Ea was also god of reproduction and of canals, but appeared under different names in his various functions, like unto Tane of the Maori.†

When wending my way homewards one day last week I met an old Native woman, who saluted me with "*Tena koe! Te mata o Te Unupo.*" By which she probably meant that the sight of me recalled to her the memory of her friend Te Unupo, who died some months ago, and who was a frequent visitor at my camp. "*Mata*" means "the face" and also "eye."

In Humboldt's account of his travels on the Orinoco he mentions a burial-cave of the Natives which he visited, and in which the exhumed bones of the tribe were deposited. "The Indians related to us that the corpse is first placed in the humid earth, that the flesh may be consumed by degrees. Some months

* "Journal of the Polynesian Society," vol. x, p. 52.

† "The Religious Ideas of the Babylonians," by T. G. Pinches.

after it is taken out, and the flesh that remains on the bones is scraped off." Many of the bones, he states, were painted red. This amiable Teuton was careful to rifle the cave tomb and carry off a mule-load of the human remains it contained.

It is with regret that I now bring this paper to a close and lay aside my pen, inasmuch as the article goes forward in very incomplete state. I have many notes on the subject which remain to be written up, but have not been able to obtain the assistance of any of the few men of knowledge left to verify and explain such items. They must be forwarded at some future time. "*Kati te tangi*; *apopo tatou ka tangi ano.*"

We have now at various times and in divers journals ushered the Maori into the world, and noted the quaint rites pertaining to reproduction. We have told of his origin, his religion, his myths and folk-lore. We have described his food-supplies, his amusements, his arts, and superstitions. His woodcraft and war-customs, his mentality and ideality, have been reviewed. We have married him, and watched him in his last hours. We have despatched his soul to the underworld, and cried him farewell to the dim shores of Hawaiki. And I do not think that we can do much more for him. Nothing remains save the *matemate-a-one.*

Art. XXVI.—*Additional Notes on the Earthworms of the North Island of New Zealand.*

By W. B. Benham, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute*, 10th *October*, 1905.]

Plate XL.

During the last twelve months I have received a few additional gatherings of earthworms from the North Island, for which I have to thank my correspondents, Messrs. Elsdon Best, H. Suter, and C. Cooper. No new area has been tapped, though I hope to obtain worms from the southern part of the Island next year. I find amongst them three new species, two of which belong to the genera *Tokea*, and *Rhododrilus*, to which the common native worms of this portion of the colony belong; a third belongs to a genus (*Dinodrilus*) the only other species of which has been obtained from the South Island.

1. **Tokea sapida**, Benham, P.Z.S., 1904 (ii), p. 245.

Of these species I only possessed a single individual at the time I wrote the account of its structure. I am now able to amplify that account. Seven individuals were received from Mr. Best.

Colour.—Alive it is dark-brown; preserved in formol, purplish-red. Some are marbled with paler streaks and patches towards the hinder end.

Dimensions.—The specimens range from 135 mm. by 6 mm. up to 290 mm. by 9 mm. A medium-sized individual contains 192 segments; the largest, 210 segments.

The *clitellum,* which was not fully developed in the type, covers segments (13) 14–18 (19)—that is, the dorsal surface of either or both the 13th and 19th may be glandular, but the segments are separated by a furrow from the rest of the organ. It completely surrounds the body, except on the ventral surface of segment 18, where a transverse depression surrounded by a ridge extends from chæta *b* to *b*. In the type this ridge has, by contraction of the body, closed over the depression.

There are no other *tubercula pubertatis.*

The *prostates* are larger than in the type, which was not fully mature; they extend back to the 26th segment. The duct is short, narrow, curved, and confined to the 18th segment.

Loc.—Ruatoki; some twenty miles inland, in the County of Whakatane. Mr. Best writes: "The worms were obtained in the foothills, where the soil is principally volcanic—pumice, &c., with a covering of humus, and a few beds of clay."

2. **Tokea maorica,** Benham, P.Z.S., 1904 (ii), p. 252.

Under this title I have confused two species, which are evidently closely allied, but which I believe are distinct. The account and figures of the external features were taken from a small species, which should, I suppose, retain this name; whereas the internal anatomy was studied on a larger species, to which a new name must be given.

I drew attention to the fact that there was a considerable range in size, in contrast to the constant number of segments. But I now find that the smaller ones possess two *tubercula pubertatis,* the larger ones only that in segment 18.

The characters of *T. maorica,* thus amended, are as follows:—

Colour.—Very dark purplish-brown, extending far down the sides of the body and along the whole length.

Dimensions.—25–35 mm. by 2 mm.; or, in soft, ill preserved specimens, 50 mm.

The *chætal* formula is $ab = aa$; $bc = cd > ab$; $dd = 2ab$.

The *clitellum* occupies segments (13) 14–17, complete.

There are two median *tubercula pubertatis,* having the disposition shown in text-figure 80 (*loc. cit.*).

The *spermathecal pores* are in segments 7/8 (not, as is stated on p. 254, by a slip of the pen, 8/9), about midway between the chætæ *a* and the hinder border of the segment.

Internal Anatomy.—The last heart is in the 12th segment.

The gizzard, in segment 5. There are no œsophageal glands.

The prostates reach into segment 24; the duct is long, narrow, curved in a sigmoid fashion (? due to contraction of the worm), and occupies two segments.

The spermatheca is an ovoid sac, with a duct of about half its diameter and length. The pyriform diverticulum opens into the duct about half-way along its course.

Loc.—Auckland: Nikau Palm Bush; Waitakerei (*H. Suter*); also "from the sheaths of nikau and *Astelia* leaves, Auckland" (*C. Cooper*).

3. **Tokea decipiens**, n. sp.

This name I propose for larger, paler, brown worms with only a single tuberculum pubertatis, of which I have some half-dozen specimens.

Dimensions.—55–75 mm. by 2 mm., with 75–90 segments.

The *chætal* formula is apparently $ab < bc < cd$; $aa = bc$; $dd = 3ab$. I write "apparently," for the body-wall is soft and therefore extensible, and the measurements made on different individuals do not give precisely the same figures.

The *clitellum* covers segments (13) 14–17 (18)—that is, in one or two individuals the dorsal surface of part of the 13th and 18th segments are glandular.

The *genital pores* as in the previous species, but there is only a single tuberculum pubertatis, on the 18th segment; none of these larger worms present any trace of one on the 14th segment.

The *spermathecal pores*, near the hinder margins of segments 7/8, behind the chætæ *a*.

Internal anatomy as described in *loc. cit.*

Loc.—Waitakerei Bush, near Auckland (*H. Suter*).

4. **Rhododrilus besti**, Benham, P.Z.S., 1904 (ii), p. 235.

The specimen from which this account was written was the sole individual in my possession at the time; since then I have received half a dozen worms that fit closely with that account.

Colour. — Mr. Best writes: "Light-coloured worms with reddish band [*i.e.*, clitellum] near head." When preserved the worms are white and the clitellum is yellow-brown to reddish-brown.

Dimensions.—They range in size from 110 mm. by 4 mm. to 220 mm. by 5 mm.; the former with 182, the latter with 226, segments.

The *chætal* formula is $ab = cd < bc$; $aa = bc = 1\frac{1}{2}ab$; $dd =$ about $3ab$.

The *clitellum* is usually on segments 14–17, though occasionally half 13 and half 18 may be glandular.

The *tubercula pubertatis* are not always so numerous as in the type: thus, in addition to a pregenital pair on segment 12 (or, as in type, on segment 11), I find three individuals with pairs on the hinder margin of segments 20, 21; two with them on 20, 21, and 22; one with them on 20, 21, 22, and 23; one with only a single pair on 20; while the type has them on segments 19, 20, 21, and 22. It is well known that these tubercles are somewhat variable, and it is not quite certain that degree of maturity is necessarily correlated with the number of tubercles, for in two of the above instances three or four pairs are present in worms in which the clitellum is not at its maximum of development.

I felt inclined to differentiate these new individuals from the type owing to the difference in the position of the pregenital tubercles, but I can detect no other important distinction.

Loc.—Ruatoki (*E. Best*).

5. **Rhododrilus similis**, n. sp.

In general appearance this worm might readily be mistaken, at least in the preserved condition, for *R. besti*, from which, however, it presents certain well-marked differences. I received about twenty specimens.

Colour.—White, with pale yellow-brown clitellum.

Dimensions.—Mature worms measure from 140–165 mm. by 5 mm., with about 200 segments, which, with the exception of the first six or seven, are annulated, whereas in *R. besti* the annulation commences on the 5th segment.

Chætæ.—In the midbody $ab = bc = cd$, approximately (but just behind the clitellum bc is about $2ab$); $aa > bc$; and $dd = 6ab$.

As is usual in the genus, the two chætæ a, b begin to approach one another at about the 25th segment, so that in the region of the male pores the couple are quite close together, but they separate again anteriorly.

The *clitellum*, (half 13) 14–17, is complete only across 14.

Genital Pores, &c.—The male pores, in line with ab, are on slight papillæ.

The *tubercula pubertatis* have rather an unusual appearance: each is a transverse group or series of glands, visible under a dissecting-lens as a series of translucent dots set on a slightly raised ridge. These tubercula are in the following groups:—

(1.) A pair on the intersegmental furrow 10/11, in line with ab.

(2.) Two transverse series, 14/15, 15/16, extending from the line *a* to *a*.

(3.) Two to four post-clitellar transverse intersegmental series, 19/20, 20/21, 21/22, 22/23.

Of these the most anterior extends from *b–b*, the last from *a–a*.

Of the seven mature individuals examined, one specimen alone had four post-clitellar tubercles, three had three, and three had only two tubercles.

There is a single pair of *spermathecal pores* nearly in line *b*, between segments 8/9.

Internal Anatomy.—The last heart is in segment 12.

The gizzard is in segment 5. The intestine commences in the 16th. There are no œsophageal glands.

The sperm-sacs are, as usual, in segments 11/12.

The prostates extend along the sides of the body to segment 21 or 22, being sharply undulating in the last two segments. The duct is very narrow, quite short and straight.

The penial chætæ (and the sacs containing them) are very short, and confined to the 17th segment. The chætæ measure only 2 mm., which is a great contrast to the length of 6 mm. attained by them in *R. besti.* Each chæta is simply curved, ending in an apparently flexible recurved tip. The shaft for some distance below the tip is "ornamented" in a very characteristic fashion; under a low power it appears serrated along each edge, but under a higher power it is seen to be pitted all round. The pits are oblique, with openings distally directed, leaving distally directed proximal edges.

The spermatheca, in segment 9, consists of a short ovoid sac lying on the outer side, and a long cylindrical portion, curved in a semicircle, towards the median line.

Loc.—Ruatoki (*E. Best*).

6. **Dinodrilus suteri**, n. sp.

Of this interesting worm three individuals were sent to me by Mr. Suter.

Colour.—Uniform dark purplish-brown (in alcohol).

Dimensions.—The largest is 40 mm. by 2 mm., with 110 segments.

The *prostomium* is half epilobic, without a transverse furrow.

Chætæ.—The peculiarity of this genus is, of course, the possession of twelve chætæ in each segment; these are almost equidistant, and their arrangement differs slightly from that given for *D. benhami:* $bc = cd = de = ef$; $ab < bc < aa$; $aa = 1\frac{1}{2}ab$; $ef = 2ab$.

Clitellum. — Unfortunately the worms are immature, and present no trace of a clitellum, but the ventral surface of segments 17–19 is rather paler than elsewhere.

Spermathecal Pores.—Two pairs, 7/8, 8/9.

Dorsal pores commence at 10/11.

Internal Anatomy.—The dorsal vessel is double, uniting at the septa. They are not enclosed in a common perivascular tube such as Beddard described for *D. benhami.*

The last heart is in segment 13.

There is a small gizzard in segment 5. Œsophageal glands are in 16/17, and the intestine begins in the 18th segment.

There is but a single pair of testes visible in sections, and these lie in segment 10; but in addition to the sperm-funnels in this segment there is a second and very minute pair in the 11th segment, rather larger than a nephridial funnel. It is possible that the absence of the testes in this segment is due to immaturity.

No sperm-sacs are developed.

The two pairs of prostates are, of course, quite small, in segments 17/19.

The two pairs of spermathecæ are in segments 8/9. Each is a subspherical sac, with a small pyriform diverticulum opening into the duct, close to the body-wall.

Loc.—Swanson, about fifteen miles from Auckland, in rotten logs.

Remarks.—The only previous record of this genus is the account given by Beddard,* in 1888, of *D benhami,* which was obtained near Lake Brunner, in Westland. This new species differs from it in its much smaller size, in position of the gizzard, the absence of the second pairs of testes, and form of the spermathecæ.

EXPLANATION OF PLATE XL.

The illustrations of the external anatomy of the earthworms described in this article are purely diagrammatic, indicating only the segmental position of the various organs, the worm being supposed to be slit up along the dorsal line and the body-wall pinned aside.

The location of the various genital pores is represented as round black dots (if on a papilla this is left white), the clitellum is obliquely shaded, the tubercula pubertatis are vertically shaded.

In addition, the arrangement of the chætæ—labelled *a, b, c, d*—is indicated in segments 5 to 23 on one side; they are omitted on the other side for clearness' sake. The true relative spacing of the chætæ is shown.

No attempt is made to give the relative sizes of the worms or of the various organs.

* Quart. Journ. Micr. Sci., xxix, p. 105.

Fig. 1. *Tokea maorica.*
Fig. 2. *Tokea decipiens.*
Fig. 3. *Rhododrilus similis.*
Fig. 4. *Rhododrilus similis.* Ventral view of the segments 19–21, showing the character of the tubercula pubertatis as seen under a dissecting-lens.
Fig. 5. *Rh. similis.* The end of a penial chæta; × 480.
Fig. 6. The same, much enlarged, showing the pittings on the surface.
Fig. 7. *Rh. similis.* A spermatheca. *d*, diverticulum.
Fig. 8. *Tokea maorica.* Spermatheca.
Fig. 9. *T. maorica.* Proximal end of the prostate, showing relative size of the duct.
Fig. 10. *Dinodrilus suteri.* A spermatheca.

Art. XXVII.—*On a Large Pterotrachæid from the Pacific Ocean.*

By W. B. Benham, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 10th October, 1905.*]

Plate XLIII.

Hitherto only a single species of the pelagic group of Gastropods, the *Heteropoda*, has been recorded from the seas that wash our coasts. This is *Carinaria australis*,* Q. and G., which was obtained in 1827, during the voyage of the "Astrolabe," between Australia and New Zealand. We may now add *Firola (Pterotrachea) coronata*, Forskål, to our marine fauna.

The specimen upon which this identification rests was washed ashore during January, 1905, at Long Beach, a few miles north of the Otago Harbour. Luckily for zoology, it was observed lying on the sandy shore and secured by Mr. W. Fels, of Dunedin, who transmitted it to me at the Museum. Unfortunately, it had been somewhat damaged by the tossing of the surf and by rolling on the sandy beach; thus the epidermis and underlying tissue was in great part rubbed off. The posterior end (metapodium) had been broken away behind the visceral hump. The visceral mass itself was a good deal damaged—only three or four gill-filaments remained of the gill—and part of the male copulatory organ was broken away. The ventral fin (or mesopodium) is also a good deal damaged, at least half of it being absent; but I believe that so much as remains suffices to establish the specific identity with *F. coronata*.

An examination of the literature available showed me that the specimen is much larger than the majority of species of *Pterotrachea (Firola)*, though *P. adamastor*, Lesson, from the

* Quoy and Gaimard, Voy. de l'Astrolabe, vol. ii, p. 394.

Cape of Good Hope, attains a length of 15 in.* But this species differs from mine in the proportions of the parts.

The "Report of the 'Challenger'" Heteropods did not enable me to carry the matter further; but my friend Mr. Charles Hedley, of the Australian Museum, to whom I applied for information on the matter, most kindly loaned me his copy of Vayssiére's "Mollusques Heteropodes."† From a comparison of the account and figures of *F. coronata* contained therein I think there is little doubt but that the present specimen is either that or a closely allied species. My only reason for doubt is a small difference in the detailed structure of the median teeth of the radula. Vayssiére remarks (p. 37) that the form of the median teeth constitutes the most reliable character for distinguishing the different species of the genus. But, in spite of the small difference to which I refer, I refrain, in the absence of an entire specimen, from creating a new species.

In the Mediterranean specimens of *F. coronata* the median denticle of the median tooth of the radula is trifid; in the Pacific specimen this denticle is, throughout the radula, single-pointed (see Plate XLIII, fig. 2). I note the same asymmetry of the smaller denticulations as he figures (pl. iii, fig. 36), though these are rather fewer in number than he gives; and in all other respects—such as shape, proportions of median tooth and of its denticulated area—this tooth agrees with Vayssiére's account and figures, as do the other teeth.

There are twenty-one or twenty-two rows of teeth (Vayssiére gives twenty-three). Possibly the tip of the radula was torn in my specimen, as the buccal mass was ruptured, and protruded from the head, and probably for this reason I was unable to find the "palatal chitinous hooklets" which Vayssiére describes. Although there are no "thorn-like" processes remaining on the body, as in *F. coronata*, yet they persist on the head, where there are two parallel rows of four, as described for that species, and below the gills.

The following measurements were taken shortly after the animal had been placed in formalin.

Body.—Total length, probably 320 mm.; length from preocular "thorns" to broken surface of visceral hump, 230 mm.; vertical diameter about midway between ventral fin and base of snout, 30 mm.; circumference of ditto, 90 mm.; distance from base of fin to base of snout, 100 mm.; distance from base of fin to level of genital pore, 60 mm.

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* Voy. de Coquille, p. 249, pl. iii, fig. 1.

† Vayssiére, Moll. Heteropodes, 1904 (pt. 26 of "Les Resultats des Campaignes Scientifiques, par Albert 1er, Prince Souveraine de Monaco").

Snout.—Length from preocular "thorns" to mouth, 110 mm.; diameter at base, 20 mm.; diameter just above buccal swelling, 10 mm.

Ventral Fin.—Length of base, 45 mm.

A comparison of proportionate sizes in my specimen and that figured by Vayssiére, which measures 260 mm., shows a close agreement. In the Pacific specimen the length of the snout is contained two and a half times in the distance from preocular thorns to genital fin, and in the Mediterranean specimen twice. In the Pacific specimen the base of sucker is contained twice in distance between it and snout, and in the Mediterranean specimen twice. In the Pacific specimen the snout-diameter to length is one-fifth, and in the Mediterranean specimen one-fourth.

Since these proportions agree pretty well, we may estimate the total length of the uninjured specimen. Vayssiére states that the distance from the visceral hump to the tip of the "tail" (metapodium) is about twice the length of the fin-base. Applying this to our specimen we should add $2 \times 45 = 90$ mm. to the above figure of 230 mm., giving a total length of 320 mm. In the same way we may estimate the size of the uninjured fin. Vayssiére's figure shows the length to be rather more than twice the base-length, and height one and a half times the base-length. So that the fin in our specimen was probably about 90 mm. in length (*i.e.*, a quarter of the total length of the body), and 67 mm. in height.

I have been unable to find any statistics as to the size of the different species of *Firola* (*Pterotrachea*); neither in Bronn's "Thierreichs" nor in the "Cambridge Natural History" do any data exist. The "'Challenger' Report" gives only a list of hitherto-described species, without details; and, as I have remarked above, the only species to a description of which I can refer that approaches this one in size is *P. adamastor*, with its 15 in., which measurement includes the length of the snout.

As figures of the genus are not readily accessible in ordinary text-books, I have deemed it advisable to give an outline of my specimen, but with the missing portions represented in dotted outline, copied from Vayssiére. I hope that people interested in natural history will keep a look-out for this and other unusual marine animals, and forward them, preserved in formol, to me at the Otago University Museum. Formol is obtainable at any chemist's, and should be used in a diluted condition, by adding ten volumes of water to one volume of formol. Animals placed in a bottle filled with this fluid, carefully corked, and packed in a small wooden box, or in shavings, &c., and properly wrapped up, can be sent for a few pence by sample post. Each such sending should be accompanied by the name and address of finder, and the locality at which the specimen was obtained.

EXPLANATION OF PLATE XLIII.

Fig. 1. Outline of a damaged specimen of a male *Firola coronata* ; × ½ : the missing parts added from Vayssiére's drawing, in a broken line.

Fig. 2. A median tooth of the radula ; × 60.

Fig. 3. The base of the snout, viewed from in front, showing the eight preocular "thorns." *a*, anus : *f*, ventral fin ; *g*, genital pore ; *m*, mouth ; *v*, visceral hump.

Art. XXVIII.—*An Account of some Earthworms from Little Barrier Island.*

By W. B. Benham, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 10th October,* 1905.]

Plates XLI and XLII.

Since the discovery that the earthworms inhabiting the North Island are so different from those of the South Island, I have endeavoured to obtain material from outlying islands, and I was successful in interesting Mr. Robert Shakespear in the matter. To him I owe the specimens with which this paper is concerned, and to him I beg to tender my thanks.

Little Barrier Island is a small outlier due west of Great Barrier Island, which is itself due north of the Coromandel Peninsula, with which it appears to have been at some previous age in continuity.

Little Barrier Island is at present a sanctuary for native birds, and is uninhabited except by the family of Mr. Shakespear, who acts as conservator of the island.

The four species which I have received are—(1) *Rhododrilus parvus*, n. sp. ; (2) *Dinodriloides annectens*. n. sp. ; (3) *Diporochæta gigantea*, n. sp. ; (4) *Diporochæta shakespeari*, n. sp.

Although these are characteristically New Zealand, they are not definitely North Island, forms, for, with the exception of *Dinodriloides*, species of the other two genera are known from the South Island ; while *Diporochæta* has not hitherto been found on the North Island itself, though it belongs to the subfamily *Megascolecinæ*, to which the characteristic North Island worms (*Tokea*) belong. *Rhododrilus* has been obtained from the Kermadecs, the Chathams, the Campbell and Auckland Islands, as well as on both the main islands of this area.

It is too early at present to draw any conclusions, for we must wait for further supplies of worms from elsewhere in the North Island. I may, however, remark that, so far as our knowledge goes, *Rhododrilus* is a commoner genus in the North Island than in the South, where it has only been met with once (*Rh. minutus*). It is surprising that no species of *Tokea* have been received from the Little Barrier Island.

I am endeavouring to trace out the line of junction between the northern and southern fauna, and am satisfied that it lies somewhere towards the south of the North Island; and, so far as my observations have gone, this line coincides in a most remarkable manner with the line recognised by Dr. L. Cockayne separating a northern and more southern flora, that line being the parallel 38° S. "The northern region is specially characterized by Malayan and Australian elements, which we may term 'subtropical'" (letter from Dr. Cockayne).

Thanks to the kindness of Messrs. Gibbs, Buchanan, and others, I have received a fairly representative supply of worms from Nelson: they all belong to the genera *Maoridrilus*, *Plagiochæta*, *Octochætus*, and *Dinodrilus*. Further, from Stephen Island, in Cook Strait, I have obtained species of *Maoridrilus* and *Octochætus*. The specific identifications of these worms I have not yet worked out, but the genera are all characteristic of the South Island. From the neighbourhood of Wellington I have received a species of *Maoridrilus* and of *Neodrilus* from Professor H. B. Kirk, in addition to the *Octochætus michaelseni* described by me in the "Proceedings of the Zoological Society" (1904, vol. ii, p. 225).

1. **Rhododrilus parvus**, n. sp.

I received three specimens, which reached me alive, packed in damp moss. Only one of them is mature.

Colour.—When alive the thin body-wall is translucent, and, except for the blood-vessels, without colour, so that the opaque white cœlomic fluid is visible. When preserved the worm is, of course, white.

Dimensions.—In comparison with the other members of the genus recently examined by me this is a small form. These three individuals measure from 55 mm. by 3 mm. (in alcohol) to 65 mm. by 2 mm. (in formol). The latter contains 120 segments, which are annulated.

The *chætal* formula is $ab = cd < bc$; $aa = bc$; $dd = 2ab$.

The *clitellum* occupies segments 14–17.

The *male pores* are in small papillæ in line of *b*.

The *tubercula pubertatis* are paired, in line with *a*, and, as in some other species, are in considerable numbers, namely, 10/11, 13/14, 14/15, 15/16, 18/19, 19/20, 20/21, 21/22. Each of these appears as a smooth rounded swelling, joined across the middle line by a slight ridge.

A single pair of *spermathecal pores* lies in line *b*, at 8/9.

Nephridiopores are also in line *b*.

Internal Anatomy.—There is nothing characteristic in regard to the alimentary system.

The testes and funnels and sperm-sacs are in the usual segments, but the anterior pair of each is smaller than the posterior pair.

The prostates extend to segment 23, and the penial sac into the 24th.

The penial chætæ are thus of considerable length, as in *R. besti*, but in form recall those of *R. leptomerus*. The chæta is delicate, curved, and terminates in a simple point, which appears to be flexible ; at any rate it is sharply recurved in the specimens mounted.

The single pair of spermathecæ lies in the 9th segment; the main sac is ovoid; the diverticulum cylindrical, not quite so long as the sac, and opens into the upper part of the short duct.

Loc.—In banks of streams in dense bush.

2. **Dinodriloides annectens**, n. sp.

I was very interested to meet with this genus again, as the type was the solitary individual obtained.

This second species is rather larger than the first, measuring 90 mm. by 3 mm. for 102 segments.

Colour.—When alive the worm is dark sienna-brown, so dark anteriorly to the clitellum as to appear nearly black. The whole dorsal surface of the body is pigmented down as far as chæta *d*—*i.e.*, the whole upper half of the body. The ventral surface is, of course, paler than the dorsal. The clitellum is much lighter brown, and the areas round the genital pores and the tubercula pubertatis are yellow; the chætæ arise from pale spots. After being in alcohol for longer than a year the colour has changed to bluish-grey, as described in the case of the previous species, *D. beddardi*,* which probably when alive is coloured dark-brown.

There is so close a resemblance between the two that for some time I supposed this new species to be merely a second specimen of the previous one. But there are one or two points of external anatomy in which this specimen differs from the type, though I can detect no differences in internal structure,

* Proc. Zool. Soc., 1904, vol. ii., p. 226.

so far as may be seen by dissection merely. Nevertheless, I believe that these external differences (which concern the position of genital pores, &c.) are sufficient to justify the bestowal of a new specific name, on the analogy of the differences between species of the European genera *Eisenia*, *Lumbricus*, &c.

Genital Pores.—The male pores, on porophores, are outside chæta *b*. Each porophore is sunk in a pit (due perhaps to mode of preservation, but suggestive of mobility in life).

There are two circular *tubercula pubertatis* on segment 16, one behind chætæ *a*, which touch mesially. A second pair on the 18th segment are in line *a* – *b*, and do not touch. A comparison with the arrangement in *D. beddardi* will show that considerable differences exist in regard to the position of these and the following structures in relation to the chætæ. Further, a well-marked ridge (? due to contraction or shrinkage of the gland), pale in colour, surrounds these four glands and the porophores. This ridge has a somewhat hexagonal form. It is transverse on the hinder margin of 15, extending from *b*–*b*; then, at each end, bends rather sharply backwards to the outer side of the porophores in 17, passing at the level of *c*; thence curving inwards between the chætæ *c* and *b* on segment 18 to meet its corresponding half on the hinder margin of this segment.*

The *oviducal pores* are immediately in front of chætæ *a*, whereas in the type they lie in front of the gap *ab*.

The *spermathecal pores*, at 8/9, are in line with *b* (instead of with the gap *bc*), and behind it is a tubercula pubertatis, on segment 9, in line with *a*.

Loc.—Bank of stream in dense bush.

3. **Diporochæta gigantea**, n. sp.

A single specimen of this titanic worm was forwarded to me.

Colour.—White (when preserved in formol), with the anterior end purplish-grey, and a narrow band of the same colour running along the dorsal surface about as far as the middle of its length.

Dimensions.—When measured after preservation its length is 990 mm. by 11 mm., but Mr. Shakespear writes me that it measured 4 ft. 6 in. when extended alive. This is a great size for an earthworm, though larger ones are known—*e.g.*, *Megascolides australis* attains a length of 6 ft. when alive, though its average size is said to be 4 ft. There is a large

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* In the case of *D. beddardi*, a re-examination of the type shows that I overlooked three medium tubercula on segments 11, 12, and 13, of which I find no evidence in the present species.

worm, *Glossoscolex giganteus*, in Brazil which when preserved measures 4 ft., and *Microchætus microchætus* from South Africa attains nearly the same length. Naturally the length of a preserved worm depends a great deal on the method of preservation and on the preservative. The present specimen was preserved in strong formol, and is much contracted.

There are about 450 segments, perhaps more. I counted 200 in less than half the length, and then estimated the total; but, as the hinder ones are smaller, this number is only approximate. The segments are much annulated, and those at the anterior end are traversed by longitudinal furrows, cutting up the surface into small rectangular areas.

Prostomium.—The prostomium and 1st segment are so much furrowed that the limits of the former are not recognisable.

Chætæ.—There are from 56–60 chætæ per segment in the 16th segment and backwards, but in front of the clitellum the number is less; about 35 were counted on the 10th segment. I was unable to detect any chætæ anterior to the 5th segment under a lens; possibly they are entirely retracted. There is a dorsal and a ventral gap along the whole length of the body, wider anteriorly; thus, on segment 16 the dorsal gap measures 4 mm. and the ventral 2 mm., but before the mid-body is reached each gap is reduced to 1·5 mm., a width which is retained throughout the rest of the body.

The *clitellum* covers segments 13 to half 18 (*i.e.*, five segments and a half).

Genital Pores, &c.—The male pores, on the 18th segment, are at either end of a transverse glandular slightly prominent area which extends from chæta *e* to *e*. The pore itself is small, inconspicuous, about in line with *c*.

Copulatory glands (*tubercula pubertatis*) are three in number, in the form of short, transverse, glandular areas, median, intersegmental, extending from *c* to *c*, and situated at 16/17, 17/18, and 19/20.

There are two pairs of *spermathecal pores*, at 7/8 and 8/9. I did not note their position in regard to the chætæ.

Dorsal pores are present behind the clitellum.

Internal Anatomy.—There are much thickened septa behind segments 7–13.

The dorsal vessel is double from the 15th segment forwards to the 8th. The last of the three pairs of hearts is in segment 12. The hearts in 11/12 are connected with the dorsal and with the supra-œsophageal vessel; those in 10 are smaller, and open out of the latter vessel only.

The gizzard, in 5, is long. The œsophagus is dilated in 12 and 13; the lining is papillose, and there are no definite glands. The intestine commences in 16, and is without a typhlosote.

The intestine contained pieces of rotten wood measuring as much as $\frac{1}{4}$–$\frac{3}{16}$ in. in length.

Reproductive Organs.—There are two pairs of testes and funnels, in the usual positions, but those in segment 10 are much the smaller, and perhaps functionless, as there is only a single pair of sperm-sacs, which lies in segment 12.

The prostates are straight,* subcylindrical, and occupy three segments. In this particular specimen the apex is directed forwards and lies in segment 16, but perhaps this is merely an individual peculiarity.

There is no definite duct. The gland retains nearly the same diameter up to the body-wall, when it suddenly diminishes as it dips into the muscles. Bundles of muscular fibres pass up from the body-wall and spread over the surface of the gland to form an imperfect sheath round its lower end.

No penial chætæ are recognisable.

There are two pairs of spermathecæ, in segments 8 and 9. Each is an ovoid pouch with a very short duct, not distinctly marked off from the sac. A small pyriform diverticulum opens into the duct close to the body-wall. The sac presents a peculiarity that I do not remember noticing in any other worm. Along both the mesial and lateral surface of the sac is a distinct muscular ridge; that on the lateral surface is larger and longer, extending right up to the apex, whereas the other one only reaches about half-way up. At the lower end these longitudinal muscle-bands spread out on the body-wall. These two ridges are very pronounced structures.

Excretory System.—The worm is micronephric, and herein differs from the majority of species of *Diporochæta*. In the genital segments the close-set little loops give a velvety appearance to the inner surface of the body-wall; but posterior to the 18th segment they become limited to a single row of small tubules running along the middle of the segment. But, although the nephridia are thus minute and multiple, the remains of a meganephric condition persist throughout the worm in the form of a pair of large funnels which project forwards from each septum. Each funnel is nearly as long as a segment —*i.e.*, in the contracted condition of the worm it reaches the preceding septum; it is thus readily visible. This funnel is V-shaped, with long parallel limbs, each consisting of an axis of vascular connective tissue, around which is arranged a single row of ciliated columnar epithelial cells, in a spiral fashion.

* In the type of the genus, *D. intermedia*, they are coiled.

There is a general resemblance to the funnel of the "brown tubes" of *Echiurus unicinctus.*

Loc.—Bush-covered plateau, 600 ft. above sea-level.

Mr. Shakespear writes, "The curious thing about these large worms is that we never see any castings about. With this one a slight crack in the soil was noticed, as when a mushroom is coming through, but there was no hole coming to the surface. My daughters dug down about 2 ft. before they came upon the worm, the passage winding horizontally, but slowly going downwards. The soil is decomposed volcanic breccia, and fairly stiff."

Remarks. — I have included this worm in the genus *Diporochæta,* for it only differs from it in being micronephric. The genus was founded in 1890 by Mr. Beddard* for meganephric worms with many chætæ and cylindrical prostates, and *D. intermedia,* from New Zealand, is the type; but since that time a number of other species have been described from Australia and Tasmania. Amongst these Spencer has included two worms having micronephridia — viz., *D. notabilis* and *D. maplestoni,* from Victoria, both of which, however, differ from the present species.

These certainly agree more closely with the typical *Diporochæta* than they do with either of the other Megascolecine genera in which many chætæ form a continuous series round each segment—viz., *Pheretima, Megascolex, Plionogaster,* and *Perionyx.* The first three are micronephric, but it is only to *Megascolex* that our species show any close resemblance, from which, however, it differs in the cylindrical character of the prostate.

I have already pointed out that within the Acanthrodriline genus *Plagiochæta,* which is normally meganephric, species (*e.g., Pl. rossi*) with small and multiple nephridia occur; and the presence of large nephrostomes in *D. gigantea* (and in the following species, *D. shakespeari*) indicates that the micronephric condition has only recently been evolved.

4. Diporochæta shakespeari, n. sp.

This new species is founded upon the results of a study of about a dozen individuals.

Colour.—The living worm is pale-red—*i.e.,* it is without pigment in the body-wall, so that the blood shows through. The clitellum is yellowish. When preserved either in alcohol or in formol the colour is opaque-white and the clitellum yellow.

Dimensions.—The formol specimens measure from 115 mm. by 4 mm. to 120 mm. by 5 mm., the latter having 195 segments.

* Proc. Zool. Soc., 1890, p. 56.

Some of those preserved in alcohol, not being so much contracted, have a length of 130 mm., but this contains only 111 segments.

The *prostomium* is about a quarter epilobic.

Chætæ.—There are about fifty chætæ in each segment ; thus, both on the 9th and 26th segments the number was forty-eight ; in the mid-body and in one of the posterior segments I counted fifty-two and fifty respectively.

A distinct ventral gap is present throughout the body, but a dorsal gap only in the anterior region. Anteriorly to segment 20 the dorsal gap equals the ventral gap, but from this segment backwards the former decreases till it has disappeared before the mid-body is reached.

The ventral gap *a–a* = four interchætal gaps (*ab*), both in mid-body and on segment 9.

The *clitellum* occupies segments half 13 – 17, and is complete.

Genital Pores, &c.—The male pores in segment 18 are carried on slight papillæ, each of which, in the formol specimen, rises from a well-defined pit about in line with *bc*.

There are two *tubercula pubertatis*, in the form of transverse glands, one near the anterior margin of segment 17, a second intersegmental at 19/20 ; each extends from about *c–c*. In the formol specimens these glands are well-marked transversely oval pits, with fairly well-marked margin, but in those preserved in alcohol they are much shallower depressions.

All the individuals, even those in which the clitellum is undeveloped, exhibit precisely the same arrangement—neither more nor fewer—of tubercula.

There are two pairs of *spermathecal pores*, at 7/8 and 8/9.

Internal Anatomy.—The septa behind segments 6 to 11 are thick.

The dorsal vessel is single, and the last heart is in 13.

The gizzard, long and cylindrical, in 5. The œsophagus is dilated in 11, 12, and 13 ; it is here thick-walled with lamellæ within, but there is no constriction from the main tube. The lamellæ, however, are similar to those in such glands as occur in *Maoridrilus*, and I think we may regard this dilated region as a gland.

The intestine commences in segment 16.

Reproductive System.—The testes and funnels are in the normal position. The sperm-sacs, two pairs, in segments 9 and 12.

The prostates—straight, tubular, with a roughened surface—extend through segments 18–24. The duct is long, straight, and narrow.

The spermathecæ, in 8 and 9, have a form common in the family; each is a pyriform sac with an ill-defined duct, into which opens a small pyriform diverticulum.

Excretory System.—Like the preceding species, this one is micronephric, but a fairly large funnel is present in each segment, of an elongated crescentic form, intermediate in form between the normal funnel and the long V-shaped funnel of *D. gigantea.*

Both this and the preceding species are provided with a pair of peptonephridia anteriorly.

Loc.—Bank of stream in dense bush.

EXPLANATION OF PLATES XLI AND XLII.

Plate XLI.

The illustrations of the anatomy of the earthworms are purely diagrammatic, indicating only the segmental position of the various organs, the worm being supposed to be slit up along the dorsal line and the body-wall pinned aside. A group of three diagrams refers to each worm herein described.

The left-hand diagram in each of the groups referring to a species represents the external features. The location of the various genital pores is represented as round black dots (if on a papilla this is left white), the clitellum is obliquely shaded, the tubercula pubertatis are vertically shaded.

In addition, the arrangement of the chætæ is indicated in segments 5 to 23 on one side; they are omitted on the other side for clearness' sake. But only about half the true number of chætæ are indicated.

The middle figure represents the alimentary canal and so much of the vascular system as is diagnostic. The latter is black. The gizzard is indicated by vertical shading, the œsophageal glands by more or less horizontal lines. The intestine is not represented as being constricted, which is, however, the case in most worms.

The right-hand figure shows the reproductive system. The gonads are in black. The sperm-sacs are dotted. The muscular duct of the spermiducal gland is transversely striped.

No attempt is made to give the relative sizes of the worms or of the various organs.

Plate XLII.

Figs. 1, 2, 3 are diagrammatic representations of the external anatomy of *R. parvus*, *D. annectens*, and *D. beddardi* respectively.

The location of the genital pores, clitellum, and tubercula pubertatis is represented, and the true relative spacing of the chætæ on one side, which are labelled *a*, *b*, *c*, *d*, &c.

The nephridiopores in *R. parvus* are indicated by the small circles on the right side of the figure.

Fig. 4. *Rhododrilus parvus.* Spermatheca.

Fig. 5. *R. parvus.* A penial chæta; × 80.

Fig. 6. The same, tip enlarged; × 480.

Fig. 7. *Diporochæta shakespeari.* A spermatheca.

Fig. 8. *D. gigantea.* Spermatheca. *r*, *r'*, the two muscular ridges along the main sac.

Fig. 9. The same in transverse section, showing muscular ridge at each end.

ART. XXIX.—*On the Anatomy of* Hyla aurea.

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[*Read before the Philosophical Institute of Canterbury, 6th December,* 1905.]

Plate XLV.

PART I.—VENOUS SYSTEM.

Hyla aurea is the common frog now found in many parts of New Zealand, where it has become plentiful since its introduction from Australia some thirty years ago. As it is one of the types put down for dissection in the University's biological laboratories, a description of its anatomy, illustrated by original drawings, will, I hope, prove acceptable.

The practical books* used in Australasia to-day all describe, as far as I can ascertain, the European form *Rana;* and though I have searched through the Transactions and Proceedings of the learned societies of Australasia, with the exception of Miss Sweet's paper† I have found nothing on the above subject. If *Hyla aurea* corresponded closely in its anatomy to *Rana*, this absence of literature on the former would not be of much consequence; but in many ways, and especially in the veins, the difference is so marked as to make the description of *Rana* more or less useless in a dissection of *Hyla aurea.*

The veins in *Hyla aurea* not only differ from those of *Rana*, but they also vary greatly in the different specimens; and in order to obtain as correct a description as possible some fifty frogs have been dissected, besides many notes have been taken from the specimens used in the biology classes.

The description here appended, though not applicable in detail to every specimen, will, I think, be found correct if a number of frogs be dissected and the most general arrangement of the veins be taken.

The following are some of the more common variations:—

1. The arrangement and size of the veins supplying the skin.
2. The size, number, and direction of the smaller branches of the external jugulars.
3. The size and branching of the lingual veins. (Out of fifteen frogs, five had these veins showing well, but they were

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* "The Frog," A. Milnes Marshall, 6th edition; "Anatomy of the Frog," Ecker (Eng. trans., Haslem). 1889; "Practical Zoology," Parker and Parker; "Atlas of Zoology," Howes.

† "Variation of the Spinal Nerves of *Hyla aurea*," P.R.S. Vic., vol. ix, new series, p. 264.

much thicker than usual; in six they were about normal; and in four they were almost if not quite invisible.)

4. The size, direction, and division of the external jugulars, which may become very much looped along their courses.

5. The division of the subclavian into its two branches. (Out of fifteen frogs, seven had the division near or at the shoulder, six about half-way between the shoulder and the vena cava, and two near the vena cava.)

6. The number of the renal veins. (These seem to vary between five and seven.)

7. The division of the anterior abdominal vein as it breaks up into the lobes of the liver. (Out of fifteen frogs, five had a large branch running into the left lobe, and the other ten had no large branch, but each lobe was supplied by several smaller branches.)

8. The size of the lumbar veins. (Out of fifteen frogs, twelve had them distinct, and in three they were very small.)

9. The size of the ileo-lumbar veins. (In some specimens they were large and distinct, while in others they were very small and indistinct.)

The lumbar and ileo-lumbar veins are often united by a connecting vein. (Out of fifteen frogs, five had a distinct and good connection, in seven a fair connection, and in three there was no connection at all visible.)

Veins from the Skin.

If fig. 1 be compared with Ecker's* it will be seen that the veins coming from the skin differ widely in the two frogs. According to Ecker, with the exception of three pairs of parietal veins near the posterior end of the abdomen, all the blood from the skin is returned through the large cutaneous veins.

Now, in *Hyla aurea* there are four centres from which the blood from the skin is returned, and this is done by four distinct pairs of veins—namely, the external jugulars, the cutaneous, the parietals, and the pelvico-cutaneous—the first three being especially noticeable.

1. The *external jugular veins* (*e.j.*) are a pair of very large and often much-twisted vessels running across the body from the angles of the jaws towards the median line just above the pectoral girdle and then disappearing through the body-wall. Some of their branches—namely, the mandibular and several other large veins—bring in the blood from the skin around the head and shoulders.

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* Ecker's "Anatomy of the Frog," Eng. trans., p. 244, fig. 161.

2. The *cutaneous veins* (*c.*) are a pair of medium-sized vessels bringing blood from the skin for a short distance posterior to the arms. Each vein is composed of a number of small branches, which arise from the skin; they unite and form the large vessel which, after running for a short distance across the ventral body-wall, disappears just below the pectoral girdle.

3. The *parietal veins* (*p.*) are a pair of veins often as large as the cutaneous, and they bring blood from the skin about half-way down the abdomen. They, like the cutaneous veins, are much branched, and the main trunk runs across the ventral body-wall and soon disappears into the body-cavity. Their course as they run to meet the anterior abdominal vein can often be traced through the body-wall.

4. The *pelvico-cutaneous veins* (*p.c.*) are a pair of veins bringing blood in from the skin around the pelvic girdle. Each vein is composed of several branches, and these uniting run through the body-wall near the junction of the legs to the trunk. If the body-wall be opened it will be seen that they connect with the renal portal veins just after the bifurcation of the femoral veins. Near the mid-ventral line and just anterior to the pelvic girdle there are often one or two very small, short veins running out to the skin.

VENOUS SYSTEM PROPER.

If the ventral body-wall be cut up a little to one side of the middle line, and the flaps laid back after the anterior abdominal vein has been dissected off, the following veins can be seen. Pin the heart back so that the ventricle is pointing towards the snout.

The *sinus venosus* (fig. 2, *s.v.*) is a thin-walled sac lying on the dorsal wall of the heart. It is more or less triangular in shape, and is made up by the union of the posterior vena cava, which enters it from the lower end, and the right and left venæ cavæ, which enter it from the right and left corners respectively.

Veins opening into the Sinus Venosus.

I. *Left Anterior Vena Cava* (fig. 1, *v.c.*).

This is a large, short vein opening into the sinus venosus at its left side, and returns blood from the left side of the head and left fore-limb. It is made up by the union of three veins—namely, the external jugular, the innominate, and subclavian—about 5 mm. from the heart, whence it runs upwards and inwards to the sinus venosus.

Veins that unite to form the Left Anterior Vena Cava.

1. *External Jugular Vein* (figs. 2 and 3, *e.j.*; and fig. 1, *e.j.*).—This is by far the largest and most important vein of the three,

and, beside returning blood from the lower jaw and tongue, it also returns it from the muscles of the shoulder, tympanic membrane, eye, nose, and the left side of the head generally. This latter group of organs is in *Rana** drained by a large branch of the subclavian vein, called the cutaneous, but in *Hyla aurea* the cutaneous (fig. 1, *c.*) does not reach much above the fore-limb.

It may also be noticed that the external jugular is not, as in *Rana*, wholly made up by the mandibular and lingual veins, but these are merely small branches joining on the main vein as it comes from the side of the head. If the skin from the side of the head be dissected off as in fig. 3 the small veins about the head that unite to form the external jugular can be seen.

The nasal vein (fig. 3, *n.*) runs from the external nares, near the edge of the upper jaw, and unites with the main trunk of the external jugular just at the angle of the jaws.

The orbital veins (fig. 3, *o.*) join the nasal as it passes the eye. They are usually two in number.

The tympanic vein (fig. 3, *t.*) is a vein bringing blood from the tympanic membrane.

There is a vein bringing blood from the dorsal muscles of the shoulder, and one bringing blood from the skin around the shoulder and head, which also join the external jugular near the angle of the jaws (fig. 3).

2. *The Innominate Vein* (fig. 2, *in.*).—This is the second and middle vein of the three that make up the left anterior vena cava. It is a very short vein, and is made up of two main branches—(*a*) internal jugular vein (fig. 2, *i.j.*), returning blood from the interior of the skull and the eyeball, and leaving the skull near the posterior border of the orbit; (*b*) subscapular vein (fig. 2, *sa.*) is a smaller vein than the former, and returns blood from the region of the scapular bone.

3. *The Subclavian Vein* (fig. 2, *sub.*).—This is larger than the innominate, but much smaller than the external jugular. It returns blood from the muscles of the shoulder and the fore-limb. It is made up of the (*a*) brachial vein (fig. 1, *br.*), which returns blood from the arm, and, after entering the body-cavity, runs direct to join with the subclavian; (*b*) the musculo-cutaneous vein (fig. 2, *m.* and *c.*, and fig. 1, *c.*) returns blood from the skin posterior to the arms, and some of the muscles of the shoulder. It does not, as in *Rana*, have anything to do with skin anterior to the fore-limbs or the head. The musculo vein returns blood from the muscles, and the cutaneous from the skin, as before described.

* Ecker's "Anatomy of the Frog," p. 244, fig. 161.

II. *Right Anterior Vena Cava.*

This vein and its branches correspond to the left.

III. *Posterior Vena Cava* (fig. 2, *p.v.c.*).

This is a large median vein, returning blood from the kidneys and reproductive organs. It is formed by five or more pairs of renal veins, and then runs forward amongst the viscera, through the liver, on to the sinus venosus. Just after emerging from the liver a pair of hepatic veins join it.

The pulmonary veins are a pair of small veins, and are often very difficult to see. They return blood from the lungs, and run along its inner side to the heart, where they unite, and open into the left auricle.

PORTAL SYSTEMS.

A. *Renal Portal System.*

The large femoral vein (fig. 2, *f.*), which comes up the leg, bifurcates as it enters the body-cavity. The ventral branch forms a portion of the hepatic portal system—namely, the left pelvic vein. The dorsal branch runs along the dorsal body-wall to the lower end of the kidney and joins it on its outer margin. This branch is the left renal portal vein (fig. 2, *r.p.*), and on its way is joined by two smaller veins. The left sciatic vein (fig. 2, *sc.*) brings blood from the back of the thigh, and, coming in from the inner side of the leg, joins the renal portal about half-way between its commencement and its junction with the kidney.

The left ileo-lumbar (fig. 2, *i.l.*) is the name I have given to a medium-sized vein bringing blood from the dorsal body-wall. It commences up near the arms, and runs down more or less parallel with the backbone, and about 10 mm. away from it, until it is near the lower end of the kidney, when it turns in and joins the renal portal just after it leaves the femoral.

The left lumbar vein (fig. 2, *lum.*) is a vein bringing blood from the dorsal body-wall by several branches, and after uniting to form a single vein it joins the renal portal vein about half-way along its length, and on its outer margin.

The right side of the renal portal system is similar to the left.

B. *Hepatic Portal System.*

The anterior abdominal (fig. 1, *a.a.v.*, and fig. 2, *a.a.v.*) is a median vein running on the under-surface of the ventral body-wall from the pelvic girdle to the liver. It is made by the union of the pelvic veins (fig. 2, *pel.*), which are the ventral branches of the femoral veins. It runs forward along the ventral body-wall until over the liver, where it runs down and breaks up into the liver at the junction of its lobes. On its way it receives the vesical vein (fig. 2, *v.*) from the bladder, also two small veins from the skin above the bladder.

The right parietal vein (fig. 1, *p.*, and fig. 2, *p.*), coming from the skin as before described, runs in at right angles and joins the anterior abdominal vein about half-way along its course.

The hepatic portal vein is rather difficult to see owing to it being obscured by the pancreas, through which it runs. It is made up of gastric vein from the stomach, intestinal and spleenic veins from the intestines and spleen respectively. The two latter form the hepatic portal by uniting at the lower end of the pancreas, and after running towards the liver it is joined by the gastric vein. The hepatic portal then runs on and joins with a large branch of the anterior abdominal vein, the ramus descendens,* which runs down from where the anterior abdominal vein breaks up into the liver for a short distance between the lobes to meet the hepatic portal. Finally it runs into the liver.

PART II.—ARTERIAL SYSTEM.

The arterial system of *Hyla aurea* corresponds pretty closely to that of *Rana*, though there are several differences. Unlike the veins, the arteries do not vary much in the different specimens.

The differences peculiar to the *Hyla aurea* are as follows :—

1. The carotid artery, before running to the head, bends back so as to overlap the systemic arch.

2. The cœliaco-mesenteric artery† (fig. 4, *c.m.*) comes off from the dorsal aorta almost at right angles, while in *Rana* it appears to come off at an angle of 45°.

3. The occipito-vertebral artery (fig. 4, *oc.*) seems to be very different in its divisions from what it is in *Rana*. In the European frog it divides into two branches soon after it leaves the systemic arch. The occipital branch supplies the back and sides of the head, while the vertebral branch runs down the back on the dorsal surface of the transverse processes of the vertebræ. In *Hyla aurea* the occipital branch is much the same as in *Rana*, but I have so far found no vertebral artery, though I have examined many fresh as well as injected specimens. The vertebral artery seems to be replaced in function by several small arteries running from the dorsal aorta and renal arteries. They are short, and supply the muscles, &c., around the vertebral column.

* "Anatomy of the Frog," Ecker, Eng. trans., 1889, p. 248, fig. 164 (*b*).

† "Anatomy of the Frog," Ecker, Eng. trans., 1889, p. 223, fig. 143 (*j*). "Atlas of Practical Elementary Zootomy," G. B. Howes, 1st ed., pl. iii, fig. xxx (*cœ*).

ARTERIAL SYSTEM OF HYLA AUREA.

The *truncus arteriosus* (fig. 4, *t.*) comes from the ventricle of the heart and divides almost immediately into two main branches. After running for a short distance each half divides into three branches, known as the "aortic arches." (For the sake of simplification, one side only—namely, the left side—will be described.)

A. *Carotid Arch* (fig. 4, *i*).—This is the upper of the three arches, and after running for a short distance it divides into two branches—viz., the lingual artery (fig. 4, *l.*), which comes off just in front of a swelling in the carotid, known as the "carotid gland," and runs forward along the muscles of the lower jaw towards the snout, breaking up into smaller branches as it proceeds; and the carotid artery (fig. 4, *c.*), which runs round the œsophagus, then, after bending backwards so as to overlap the systemic arch, runs forwards and downwards and enters the skull a little to the left of the median line. I have not been able to make out very clearly the course of the carotid artery after it enters the head, but it appears to divide up into internal and external carotids.

B. *Systemic Arch* (fig. 4, *ii*).—This is the middle of the three arches, and runs round and down over the œsophagus to the dorsal body-wall. It then continues on as a large artery and joins with its fellow on the other side, just anterior to the kidneys, to form the dorsal aorta. When opposite the arm this arch gives off two arteries, viz. :—

(*a.*) The occipito-vertebral (fig. 4, *oc.*) : This is seen as a very short, thick artery running downwards and forwards, and disappears into the muscles of the dorsal body-wall. In *Rana* this divides into two branches—namely, the occipital and the vertebral—but in *Hyla* I have only been able to make out the occipital (fig. 4, *oc.*), which runs up to the muscles on the side of the head and also to the orbit.

(*b.*) The subclavian artery (fig. 4, *s.*) branches off from the systemic arch near the origin of the occipital vertebral. It runs out as a large artery to supply the arm.

C. *Pulmo-cutaneous Arch* (fig. 4, *iii*).—This is the third of the aortic arches, and just before it reaches the lung it divides into two, viz. :—

(*a.*) The cutaneous artery (fig. 4, *cu.*) runs outwards and downwards, and disappears in the muscles at the angle of the jaws. It can be traced to the dorsal surface, where it runs as a large vein along the skin from the pectoral down to the pelvic girdle. It has a number of small branches which supply the skin.

(*b.*) The pulmonary artery (fig. 4, *pl.*) bends round and runs down the outer side of the lung, through which it ramifies.

The *dorsal aorta* (fig. 4, *d.a.*), as stated before, is made up by the union of the right and left systemic arches. It runs down close to the vertebral column, and just below the kidneys it divides into the two iliac arteries (fig. 4, *il.*), which supply the legs.

Just where the two systemic arches unite, a large median artery, the cœliaco-mesenteric (fig. 4, *c.m.*), is given off to the viscera. This divides into two smaller arteries—viz. (*a*) Cœliac artery (fig. 4, *cœ.*), which breaks up again into (1) the hepatic artery, running to the gall-bladder and liver, and (2) the gastric artery, supplying the stomach; (*b*) mesenteric artery (fig. 4, *m.*), which breaks up again into (1) the anterior mesenteric, supplying the duodenum and the proximal end of the intestine, and (2) the posterior mesenteric, supplying the distal end.

Just as the iliac artery passes the pelvic girdle it gives off two or three branches that supply the body-wall and some of the muscles of the thigh; these seem to be what Marshall* calls the "lumbar" (fig. 4, *lm.*), and Ecker† the "external iliac arteries."

EXPLANATION OF PLATE XLV.

Fig. 1. Venous system of *Hyla aurea* (enlarged). (Ventral surface with the skin laid back on one side, showing the veins of the skin. Dotted lines indicate the position of the veins that can often be seen through the body-wall.)

e.j. External jugular.
p.c. Pelvico-cutaneous.
p. Parietal.
m. Mandibular.
a.a.v. Anterior abdominal.
c. Cutaneous.

Fig. 2. General view of the venous system of *Hyla aurea* (partly diagrammatic). (Portal systems in black.) (Enlarged.)

s.v. Sinus venosus.
v.c. Left anterior vena cava.
p.v.c. Posterior vena cava.
e.j. External jugular.
in. Innominate.
sub. Subclavian.
l. Lingual.
m. Mandibular.
i.j. Internal jugular.
sa. Subscapular.
br. Brachial.
m. Musculo.
c. Cutaneous.
r. Renal veins.
h. Hepatic.
a.a.v. Anterior abdominal vein.
pel. Pelvic.
f. Femoral.
p. Parietal.
lum. Lumbar.
i.l. Ileo-lumbar.
r.p. Renal portal.
sc. Sciatic.
v. Vesical.
h. Heart.
liv. Liver (diagrammatic).

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* "The Frog," A. Milnes Marshall, 7th ed., p. 31 (*b*, 3).

† "Anatomy of the Frog," Ecker, Eng. trans., 1887, p. 223, fig. 143 (*i*, *e*).

Fig. 3. Side view of the head with the skin laid back, showing the branches of the external jugular vein.

n. Nasal.	*t.* Tympanic.
o. Orbital.	*e.j.* External jugular.

Fig. 4. The arterial system of *Hyla aurea* (partly diagrammatic). (The dotted lines indicate the position of arteries that are hidden by muscles, &c. The carotid artery is made not to overlap the systemic arch, so to avoid confusing the diagram.)

h. Heart.	*cu.* Cutaneous artery.
t. Truncus arteriosus.	*c.m.* Cœliaco-mesenteric.
i. Carotid arch.	*d.a.* Dorsal aorta.
ii. Systemic arch.	*il.* Iliac artery.
iii. Pulmo-cutaneous arch.	*lm.* Lumbar artery.
l. Lingual artery.	*cœ.* Cœliac artery.
c. Carotid artery.	*m.* Mesenteric artery.
s. Subclavian artery.	*g.* Gastric artery.
oc. Occipital artery.	*r.* Renal arteries.
o.c. Occipito-vertebral artery.	*gl.* Carotid gland.
pl. Pulmonary artery.	

ART. XXX.—*Report of some* Crustacea *dredged off the Coast of Auckland.*

By CHARLES CHILTON, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College, New Zealand.

[*Read before the Philosophical Institute of Canterbury, 6th December,* 1905.]

SHORTLY after the Dunedin meeting of the Australasian Association for the Advancement of Science, some dredging was done off the coast of Auckland by Messrs. Hedley, Suter, and others. The small number of *Crustacea* that were taken were kindly handed over to me for identification by Mr. H. Suter, and the following report is the result. I have included one or two specimens sent to me later on by Mr. Suter, and some dredged early in 1905 off the Poor Knights Islands by Captain Bollons of the "Hinemoa." Most of the specimens were taken in the Hauraki Gulf at a depth of 25 fathoms, and there were only four taken outside Great Barrier Island in 120 fathoms—viz., a Callianassid, not identifiable; *Lyreidus tridentatus*, De Haan; *Cirolana rossii*, Miers; and *Ampelisca chiltoni*, Stebbing.

None of the species given below are new, though one or two of the *Sphæromidæ*, which I am unable to identify satisfactorily at present, may prove to be new species. There are, however, one or two interesting additions to our knowledge of the distribution of species already known, the most important being that of *Lyreidus tridentatus*, De Haan, which is now recorded from New Zealand for the first time, and belongs to a group of the *Anomura*—the *Raninidea*—hitherto unrepresented in the New Zealand fauna.

Brachyura.

Paramithrax peronii, M.-Edwards. Miers, Cat. N.Z. Crust., p. 5; Index Faunæ N.Z., p. 247.

Several specimens from Channel Island, 25 fathoms, and one from 30 fathoms, appear to belong to this species, but they are very small, the largest having the carapace not more than 15 mm. long.

Pinnotheres pisum, Linnæus. Miers, Cat. N.Z. Crust., p. 48; Index Faunæ N.Z., p. 250.

One small male specimen from Channel Island, Hauraki Gulf, 30 fathoms, appears to agree well with the description. As is frequently the case with males, this specimen was found free and not in a bivalve shell.

It is perhaps worthy of note that Heller's "Novara" specimens, which he identified with the *P. pisum* of Europe, were from Auckland, found in *Mytilus*.

Ebalia lævis, Bell. Miers, Cat. N.Z. Crust., p. 56; Index Faunæ N.Z., p. 251.

Three specimens from Channel Island, 25 fathoms. I have also two specimens dredged off the Poor Knights Islands in 60 fathoms by Captain Bollons early in 1905.

Through the kindness of Mr. F. E. Grant I have been able to compare this species with specimens of *E. tuberculosa* (Milne-Edwards) taken off Sydney at the depth of 300 fathoms; from these *E. lævis* may be distinguished by the smoother carapace, and by having the posterior margin produced so as to give the appearance of three obtuse teeth. Mr. G. M. Thomson has recorded *E. tuberculosa* from Dusky Sound, 40 fathoms. It was taken by the "Challenger" at station 167, about a hundred and fifty miles west of New Plymouth, in 150 fathoms.*

Anomura.

Lyreidus tridentatus, De Haan. Haswell, Cat. Aust. Crust., p. 144; and Henderson, "Challenger," Anomura, p. 33.

One specimen was taken outside Great Barrier Island in 120 fathoms. This agrees well with the description given by Haswell. The prominent dorsal elevations on the 3rd and 4th abdominal segments are present as described by Henderson, except that the one on the 3rd is almost acute, though much smaller than the one on the 4th.

The species was originally described from Japan, and was taken by the "Challenger" off Port Jackson and also near the Fiji Islands, but it has not been previously recorded from New Zealand.

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* Annals and Mag. Nat. Hist., 7, x, p. 462.

Eupagurus edwardsi, Filhol. G. M. Thomson, Trans. N.Z. Inst., xxxi, p. 182; Index Faunæ N.Z., p. 251.

Two specimens, from Channel Island, Hauraki Gulf, 25 fathoms. These agree very well with the descriptions given by Thomson and Filhol. One is a fairly large specimen, with carapace about 15 mm. long; the other has the carapace not more than 10 mm. long. In the latter the propodos of the right chelipede bears few tubercles on its outer surface, and those present are small and somewhat spiny.

In some points this species shows a marked resemblance to *E. spinulimanus,* Miers, and I should not be surprised if the two prove to be identical. I have two or three small specimens from Auckland, collected by Dr. Cockayne in 1905, which also belong to this species, and are almost more like *E. spinulimanus.*

Stratiotes setosus, Filhol. G. M. Thomson, Trans. N.Z. Inst., xxxi, p. 185; Index Faunæ N.Z., p. 252.

Several specimens from Channel Island, 25 fathoms. These are much smaller than the specimen in the Canterbury Museum that was examined and named as above by Mr. Thomson, but they agree closely with his description.

Petrolisthes novæ-zealandiæ, Filhol. Thomson, Trans. N.Z. Inst., xxxi, p. 190; Index Faunæ N.Z., p. 252.

Two small specimens from Channel Islands, 25 fathoms, appear to belong to this species, but they are too young for certain identification.

Galathea pusilla, Henderson. Thomson, Trans. N.Z. Inst., xxxi, p. 193; Index Faunæ N.Z., p. 252.

Two specimens from Channel Islands, 25 fathoms. This species was previously known in New Zealand from Cook Strait, Wanganui, and Paterson's Inlet, and was obtained by the "Challenger" off the south-east of Australia.

Amphipoda.

Amaryllis macropthalmus, Haswell. *Amaryllis macrophthalmus,* Haswell, Proc. Linn. Soc. N.S.W., iv, p. 253; Cat. Aust. Crust., p. 227. *Amaryllis brevicornis,* Haswell, *l.c.,* p. 254; Cat. Aust. Crust., p. 228. *Glycerina affinis,* Chilton, *l.c.,* ix, p. 2, pl. xlvii, fig. 1, *a* and *b*. *Amaryllis macrophthalmus,* Stebbing, "Challenger," Amphipoda, p. 706, pl. xxix. *Amaryllis macrophthalmus,* Thomson, Annals and Mag. Nat. Hist., 7, x, p. 463; Index Faunæ N.Z., p. 258.

A single specimen, a female with eggs, from Channel Islands, 25 fathoms, undoubtedly belongs to this species. The species is a widely distributed one. Haswell records it from Tasmania, Port Jackson and other localities on the east coast of Australia; while the "Challenger" specimen was obtained off Cape Virgins, Patagonia, at a depth of 55 fathoms. *Glycerina affinis*, Chilton, which was described under a misapprehension as to its generic position, is a synonym of this species.

Mr. G. M. Thomson has recorded this species from Mokohinau and from Lyttelton.

Ampelisca chiltoni, Stebbing. Index Faunæ N.Z., p. 260, and Report "Challenger," Amphipoda, p. 1042.

One imperfect specimen dredged off Great Barrier Island, at a depth of 120 fathoms, appears to belong to this species. I have also two specimens dredged off the Poor Knights Islands, in 60 fathoms, and two others collected in Kaipara Harbour by Dr. Cockayne, that certainly belong to it.

The "Challenger" specimens were collected at station 167, to the west of New Plymouth, in 150 fathoms.

Ampelisca acinaces, Stebbing. Index Faunæ N.Z., p. 260; Thomson, Annals and Mag. Nat. Hist., 7, x, p. 464.

Some specimens from Bay of Islands, 4 fathoms, given me by Dr. Cockayne, belong, I think, to this species. They can be distinguished from *A. chiltoni* most readily by the dorsal compression, which is continued along the whole length of the body, whereas in *A. chiltoni* it is not at all well marked, and is limited to the head. Many minute points of difference are given by Mr. Stebbing, but if my identifications are correct some of these will not hold: *e.g.*, the inferior posterior angles of the 3rd segment of the pleon are produced into an acute slightly upturned point, just as in *A. chiltoni*, while Mr. Stebbing describes and figures the lower margin as nearly straight, and making a right angle with the hind margin; and again, in my specimens the lower antennæ are considerably less than the length of the body and shorter than in *A. chiltoni*, while Mr. Stebbing gives them about equal to the length of the body in *A. acinaces*, and his figure of *A. chiltoni* shows them considerably less than that of the body, although in his description of the species he says, "antennæ nearly as in *Ampelisca acinaces*."

The "Challenger" specimens were taken off Port Jackson in 35 fathoms. According to Mr. Thomson, this species is not infrequently washed up on Ocean Beach, Dunedin, in considerable numbers.

Leucothoë tridens, Stebbing. "Challenger" Reports, xxix, p. 777; Index Faunæ N.Z., p. 258.

Two imperfect specimens, Channel Islands, 25 fathoms, appear to belong to this species.

ISOPODA.

Cirolana rossii, Miers. Cat. N.Z. Crust., p. 109; Index Faunæ N.Z., p. 263.

One small specimen, dredged off Great Barrier Island, appears to belong to this common species, but it is immature, and the eyes very indistinct, so that the identification is not free from doubt.

Among the *Isopoda* were two or perhaps three species of *Sphæromidæ*, one apparently belonging to the genus *Cilicæa*, and new to New Zealand. But I cannot identify these with existing species, and do not care to venture on the description of new species of this difficult family pending the appearance of Dr. H. J. Hansen's work on the genera of the group.

ART. XXXI.—*List of* Crustacea *from the Chatham Islands.*

By CHARLES CHILTON, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College, New Zealand.

[*Read before the Philosophical Institute of Canterbury, 6th December,* 1905.]

IN connection with the origin of the fauna of New Zealand that of the outlying islands is of especial importance, and I am therefore giving here a list of some *Crustacea* from Chatham Islands, a group situated about 450 miles east from Lyttelton Harbour. It will be seen that the list is a very short one, and this must necessarily be the case, for no systematic collection of the *Crustacea* has been so far made, and I have only a few specimens that have been gathered at odd times by Mr. A. Shand, Miss S. D. Shand, Professor Kirk, and Dr. Dendy. The list, indeed, would be hardly worth while publishing of itself, but I hope that it will be the means of causing others who may have the opportunity of doing so to pay special attention to the fauna and flora of these and other outlying islands of New Zealand. The terrestrial and fresh-water faunas are of the greatest value in this connection, and it is of extreme importance that they should be studied, and if possible preserved, before it is too late.

BRACHYURA.

Paramithrax latreillei, Miers. Index Faunæ N.Z., p. 247

Numerous specimens from Te Whakuru (*Miss Shand*).

Platyonichus bipustulatus, M.-Edwards. Index Faunæ N.Z., p. 249.

From Te Whakuru (*Miss Shand*).

Halicarcinus planatus, Fabr. Index Faunæ N.Z., p. 250; Stebbing, Proc. Zool. Soc., 1900, p. 524.

Numerous specimens from Te Whakuru (*Miss Shand*).

Hymenicus marmoratus, Chilton. Index Faunæ N.Z., p. 250.

Specimens from Te Whakuru (*Miss Shand*) agree with the type specimen, which came from Lyttelton, but I am doubtful whether the species is a good one; it may be identical with one of those described by earlier authors. A revision of the New Zealand *Hymenosomidæ* is very much needed; and I allow the species to stand in the meantime till full comparison with others can be made.

Elamena producta, T. W. Kirk. Index Faunæ N.Z., p. 251.

A male specimen from Ouenga (*Dr. Dendy*) agrees with Kirk's description and figures. Kirk's specimens were from Wellington; I have seen no specimens from the South Island.

Macrura.

Palæmon affinis, M.-Edwards. Index Faunæ N.Z., p. 255.

Numerous specimens of this common species were sent by *Mr. Shand.*

Xiphocaris curvirostris (Heller). Index Faunæ N.Z., p. 255; Thomson, Trans. Linn. Soc., Zool., viii, p. 447.

Numerous specimens brought to me by *Mr. Shand* from Chatham Island (fresh water); they seem to be quite the same as those found so abundantly in the Avon, Heathcote, and other New Zealand streams.

Mr. G. M. Thomson has already pointed out that it is noteworthy that the fresh-water shrimp found in Australia and Norfolk Island, *Xiphocaris compressa*, De Haan, is quite different from that found in New Zealand streams.

Stomatopoda.

Lysiosquilla spinosa (Wood Mason). Index Faunæ N.Z., p. 256.

This species has been recorded from the Chatham Islands, under the name *Squilla indefensa*, by Mr. T. W. Kirk (Trans. N.Z. Inst., xi, p. 394).

Amphipoda.

Orchestia chiliensis, M.-Edwards. Index Faunæ N.Z., p. 257.

I have some specimens from Te Whakuru (*Miss Shand*) that must, I think, be referred to this species as defined by Mr. G. M. Thomson (Trans. N.Z. Inst., xxxi, p. 199).

Moera fasciculata, G. M. Thomson. Index Faunæ N.Z., p. 260.

Numerous specimens from Te Whakuru (*Miss Shand*), some of them rather larger than those usually taken on the east coast of the South Island, where the species is common. I do not feel sure of the generic position of this species; the secondary flagellum of the upper antenna consists of a single small joint, and the species does not exhibit marked sexual differences, and is very different from other species of *Moera* that I am acquainted with. I am of the opinion that it comes near to *Atyloides*, Stebbing.

Melita tenuicornis, Dana. Index Faunæ N.Z.. p. 260.

One specimen collected by *Dr. Dendy.*

This species is common in New Zealand, and is found both in rock-pools on the open sea-coast and also in estuaries and lagoons when the water may be almost or quite fresh.

Mr. A. O. Walker has recently recorded it from Ceylon under the name *Mæra tenuicornis*, though pointing out that there are various discrepancies between his species and Dana's description and figures of the New Zealand form.* In the same year Mr. Stebbing described from Ceylon a new species, *Melita zeylanica*, which he was unable to refer to Dana's species, and distinguishes from it by numerous characters, though he appears to think that these differences may possibly be due to errors and inconsistencies in Dana's descriptions and figures.†

Phronima novæ-zealandiæ, Powell. Index Faunæ N.Z., p. 256.

Two specimens in the "casks" washed upon Te Whakuru Beach (*Miss Shand*), one with numerous young with her in the "cask."

Isopoda.

Exosphæroma gigas, Leach. Index Faunæ N.Z., p. 263.

Several specimens of this widely spread species were in Mr. Thomson's collection, having been collected by Professor H. B. Kirk. Some of them were larger than those usually found on the east coast of the South Island, being intermediate between these and the large specimens found at the Auckland Islands. On the Chatham Islands specimens were found *Iais pubescens*, Dana, which appears to be almost invariably associated with this species.

Mr. Stebbing has fully described *Exosphæroma gigas* from Falkland Island specimens, and has established for it the genus

* *Amphipoda*, from "Report on the Pearl Oyster Fisheries," 1904, p. 273.

† "Spolia Zeylanica," vol. ii, part v, p. 22.

Exosphæroma, which differs from *Sphæroma* in having the last three joints of the maxillipeds lobed on the inner side.

Cymodoce huttoni (G. M. Thomson). Index Faunæ N.Z., p. 263.*

One specimen collected by *Professor H. B. Kirk*. This species is very common all round the coasts of New Zealand, and I have specimens also from the Antipodes Islands (*Dr. L. Cockayne*). It appears to be closely allied to *Dynamene eatoni*,† Miers, from Kerguelen, which is recorded also from Cape Horn by M. Adrien Dollfus in the "Mission du Cap Horn," Crust., p. F, 66.

(?) Isocladus spiniger (Dana). Index Faunæ N.Z., p. 263.

Numerous specimens from Te Whakuru (*Miss Shand*). These differ in several points from Lyttelton and other specimens that I have been in the habit of referring to Dana's species, and may prove to be a new species. They are rather larger, and lack the small teeth at the base of the large spine arising from the last segment of the pereion. The colour is brownish with darker markings, the edges of the epimera, bases of the antennæ, &c., being reddish.

Paridotea ungulata (Pallas). Index Faunæ N.Z., p. 264.

Specimens from Te Whakuru (*Miss Shand*). This species is widely distributed in the southern seas. Stebbing in his "Report on the South African Crustacea," pp. 53–55, instituted for it the new genus *Paridotea*, and describes the mouth parts and other structures more fully than had hitherto been done. He points out that his large dredged specimens have the 4th, 5th, and 6th joints of both gnathopods and first four pereipods thickly coated with hair on the inner margin, while the corresponding parts in the smaller beach specimens sent to him were comparatively smooth. I have taken specimens of both kinds together in shallow water on the sea-beach, and can state that the differences are sexual—the fine woolly hairs being found on these parts in large fully developed males, but not in the mature females, and probably not in immature males.

Idotea peronii, M.-Edwards. Index Faunæ N.Z., p. 264.

Three specimens from Te Whakuru (*Miss Shand*), reddish-brown or orange in colour (in formalin). One is a female with eggs in pouch, and has the 2nd, 3rd, and 4th segments of pereion somewhat expanded. The colour and markings of this species, though variable, are very protective, and resemble those of the red seaweeds on which it is found. One specimen has a median

* This species cannot remain in the genus *Cymodoce* as now defined by Hansen. It appears to belong to the new genus *Dynamella*, Hansen. See Q.J.M.S., vol. xlix, p. 107.

† Annals and Mag. Nat. Hist., xvi, p. 73 (1875).

white line about 2 mm. wide, extending from the cephalon all through the pereion and half-way along the pleon, the rest of the body reddish-brown. Another has white markings on the margins of the epimera, the third (female) without any white markings.

Iais pubescens, Dana. Index Faunæ N.Z., p. 264.

Numerous specimens found in the bottle, in which the only Sphæromids were the specimens of (?) *Isocladus spiniger*, Dana, mentioned above, and I have no doubt they were commensal on this species. They appear quite the same as those found on *Sphæroma gigas*, Leach. This species occurs throughout the southern seas as a commensal on several Sphæromids. Mr. Stebbing has given a full description of it in the Proc. Zool. Soc., 1900, p. 549–51.

Deto novæ-zealandiæ = *Oniscus novæ-zealandiæ*, Filhol, "Mission de l'Ile Campbell," p. 441, pl. liv, fig. 7.

Among some *Crustacea* sent from Te Whakuru Beach by *Miss Shand* (August, 1903) are three imperfect specimens that evidently belong to this species. The rounded swollen granular prominence on each side of the 1st segment of the mesosome is very characteristic, and agrees well with Filhol's figure and description: "*Le premier anneau du corps présente chez certains sujets, de chaque coté, à ses extrémités, une saillie arrondie, globuleuse, couverte de très fines granulations.*"

Actæcia aucklandiæ, G. M. Thomson (Trans. N.Z. Inst., xi, p. 249), which I provisionally placed under *Scyphax* in 1901 (Trans. Linn. Soc., viii, p. 126), also belongs to the genus *Deto*, and is distinguished from *D. novæ-zealandiæ*, among other points, by the absence of the rounded prominences on the 1st segment of the pereion. I am preparing a fuller paper on these and other species of *Deto*.

Oniscus punctatus, G. M. Thomson. Index Faunæ N.Z., p. 265.

Two or three specimens from Pitt Island (*Dr. Dendy*). Dr. Budde-Lund informs me that he has established a new genus, *Phalloniscus*, for this and other allied species, but I have not yet received the paper in which this genus has been published.

Armadillo speciosus, Dana. Index Faunæ N.Z., p. 266.

In 1901 I referred some specimens from the Chathams in Mr. Thomson's collection to this species with some hesitation. I have since received further specimens of the same kind from Pitt Island, collected by *Dr. Dendy*, and think they must belong to Dana's species, but it is very difficult to know exactly what species was intended by some of the early descriptions. Dana's specimens were from the Bay of Islands.

Art. XXXII.—*Description of a Species of* Phreatoicus *from the Surface Waters of New Zealand.*

By Charles Chilton, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College, New Zealand.

[*Read before the Philosophical Institute of Canterbury, 6th December,* 1905.]

In my paper on the subterranean *Crustacea* of New Zealand published in 1894 (Trans. Linn. Soc., vi), when discussing various questions in connection with the three species of *Phreatoicus* known at that time, I said, "The questions suggested may perhaps be some day solved by the discovery of species of *Phreatoicus* still living above ground in the mountain-streams of the Southern Alps, places where very little search of the kind required has hitherto been made" (*l.c.*, p. 202). I am not sure that the questions under consideration are very much nearer solution now than they were then, and certainly no species of *Phreatoicus* has yet been found among our Southern Alps; but in making the statement quoted I little anticipated that within the next twelve years so many species would be found in other places.

At that time there was known only the one genus, with three species—two found underground in New Zealand, and the third on the Mount Kosciusko plateau, in Australia. Now, thanks to the researches of Mr. G. M. Thomson, Professor Baldwin Spencer, Mr. T. S. Hall, and particularly of Mr. O. A. Sayce, we are acquainted with five species of the genus *Phreatoicus*, and with no less than three other closely allied genera, each with one species. All these additional forms, however, were from Australia and Tasmania, and up to 1902 no surface form had been recorded from New Zealand. In that year, however, Mr. (now Professor) H. B. Kirk brought me specimens of a *Phreatoicus* found in a fresh-water lagoon in Ruapuke Island, in Foveaux Strait. These were exhibited at a meeting of the Philosophical Institute of Canterbury on the 26th November, 1902 (see Proc. N.Z. Inst., xxxv, p. 564), but no description has as yet been published. In the present year (1905) specimens of the same genus were found at Mosgiel, and afterwards at Woodhaugh, both places being near Dunedin. These have been very kindly handed over to me for examination by Mr. G. M. Thomson.

The occurrence of the species at Woodhaugh reminds us how little we really know of the smaller animals even of places that have been fairly well searched, for Mr. Thomson and myself, and probably many others, have made many collections from this locality without coming across the species in question, although it is by no means a particularly small one, some of the specimens being nearly 1 in. in length. Judging from Mr. Sayce's experience in Australia, it is quite probable that other forms are still to be found from the streams and fresh waters of New Zealand, and I shall be grateful to any collectors who will send me any shrimp-like creatures they may find under stones or in moss in such situations.

From the description given below it will be seen that the species now to be described, though found in surface waters, is a blind one, and that it is whitish in colour, in these respects resembling the two subterranean species occurring in the underground waters of the Canterbury Plains.

Phreatoicus kirkii, sp. nov.

Specific Diagnosis.—General appearance of the body and appendages very similar to that of *P. assimilis*. Eyes not visible. Body rather stout and compact, the segments of the pereion fitting closely to one another; pleura of the 2nd to 5th segments of the pleon largely developed, fully as deep as their segments and concealing the pleopoda, rounded below and with the inferior margin and the lower part of the hind margin thickly fringed with long setæ; 5th segment as long as the 3rd and 4th together; inferior margin of the 6th segment with six curved setæ which increase in stoutness posteriorly, the last being very stout; the projection at the end of the last segment narrower (as seen in side view) than in *P. assimilis*, longer than broad, tipped with two or three stout setæ and bearing also several more slender ones; below this the hind margin on each side is irregularly convex, and bears numerous short setæ of varying degrees of stoutness. Surface of body with a fair number of slender setæ arranged singly or in small tufts, and becoming more numerous posteriorly, especially on the last segment of the pleon. Lower antennæ scarcely half as long as the body; flagellum of about twelve joints, not much longer than the peduncle. Pereiopoda as in *P. assimilis*, rather short and very spiny; the 1st forming in the male a powerful subchelate claw of the same general structure as in *P. assimilis*, but with the anterior produced portion of the meros armed with one stout seta and a few slender ones in place of the thick brush of fine hairs found in *P. assimilis*; 4th pereiopod of male shorter than the 3rd and specially modified. In the female the 1st pereiopod has the subchelate claw much smaller and like that described for *P. typicus*, and the 4th pereiopod is similar to the 3rd. The last three pairs of pereiopoda with the basa considerably expanded. The mouth parts are practically the same as in *P. assimilis*, the lower lip having the lobes rounded, and the inner lobe of the first maxilla bearing only four plumose setæ.

Colour.—Whitish.

Length—cephalon, 2·5 mm.; pereion, 8·5 mm.; pleon, 6·5 mm. Depth—pereion, 2 mm.; pleon, 3·5 mm.

Hab.—Fresh-water lagoon on Ruapuke Island.

The description given above applies to the Ruapuke Island specimens. Those from the neighbourhood of Dunedin differ considerably in general appearance, having the segments of the pereion longer, so that the appendages are more separated, and there are also some minor differences. I was at first inclined to consider them as a separate species, but the resemblances in the appendages are so close, and the differences rather in the proportions of the body—characters difficult to estimate precisely, and perhaps partly due to shrinkage caused by the preserving-fluids used—so that I propose to consider them as a variety.

Phreatoicus kirkii, var. dunedinensis, nov. var.

Differing from the type in having the segments of the pereion rather longer, more slender, and more separated; the dorsal surface of body, especially of the last segment of pleon, with more numerous setæ; pereiopoda more slender, the basa of the last three pairs less expanded.

Colour.—Whitish.

Length—cephalon, 2·5 mm.; pereion, 13 mm.; pleon, 7 mm. Depth—pereion, 2 mm.; pleon, 3·5 mm.

Hab.—Streams at Mosgiel and Woodhaugh, near Dunedin.

Mr. Sayce has laid considerable stress on the proportion of the length of the pleon to that of the cephalon and pereion combined in the various species of *Phreatoicus* and allied genera. If we take the measurements given above and work them out as Mr. Sayce has done we find that in the typical specimens the pleon is $\frac{59}{100}$ of the combined length of cephalon and pereion, while in the variety *dunedinensis* the corresponding fraction is only $\frac{45}{100}$, the difference being thus considerable. Measurements of this kind are, however, not easily made with the same accuracy in all cases, and they vary to some extent in different individuals, and certainly these fractions in the present instance would lead one to think that the specimens from the different localities differ more than they really do.

It will be seen that the present species is very closely allied to *P. assimilis*, and that in the lower lip and the inner lobe of the first maxilla it agrees with this species and with *P. australis* and *P. shephardi*, and differs from *P. typicus*.

In the structure of the last segment of the pleon, and in some other points, it may be considered to be intermediate between *P. australis* and *P. assimilis*.

ART. XXXIII.—*Note on the Occurrence in New Zealand of Dipterous Insects belonging to the Family* Blepharoceridæ.

By CHARLES CHILTON, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 6th December, 1905.*]

Plate XLVI.

SOME three years ago Mr. G. R. Marriner brought me some peculiar insect-larvæ that he had obtained from a mountain-stream near Lake Coleridge. Afterwards, in February, 1903, I collected similar larvæ in a rocky stream at Akaroa. These prove to belong to the Dipteran family *Blepharoceridæ*, a family that does not appear to have been hitherto recorded from New Zealand; and, though I have as yet been unable to collect the adult insects or to rear them from the larvæ, I have thought it desirable to give a brief description of the larvæ, with one or two notes on the family taken from Dr. Sharp's volume in the "Cambridge Natural History,"* in the hope that the attention of entomologists may be thereby directed to these insects.

The *Blepharoceridæ* constitute a small and little-known family of the *Diptera*, and are found in Europe (the Pyrenees, Alps, and Harz Mountains), and in North and South America. The adult insects resemble the *Empidæ*, but have strongly iridescent wings, and they execute aerial dances after the manner of midges.

The *larvæ* are very peculiar in appearance, and are aquatic, living in rapid rocky streams, clinging firmly to the rocks by means of suckers on the ventral surface. According to Dr. Sharp, they live only a short time when taken out of the highly aerated water in which they exist.

The larvæ that I have present a close resemblance to that of *Curupira torrentium*, Fritz Müller, from Brazil. They are about 7 mm. long and 2·5 mm. broad; dorsal surface moderately convex, ventral surface flat. The larva consists of six divisions, on the ventral surface of each of which is a rather large round sucker, and each division except the last bears one pair of projecting side lobes; the last division bears two pairs, and shows marks of being really composed of two divisions. The cephalothorax—*i.e.*, the first segment—is larger than either of the four succeeding divisions, and is about the same size as the last; the mouth is situated on its ventral surface immediately in front of the sucker. The short antenna of two joints, slender, free

* "Insects," part ii, by David Sharp ("Cambridge Natural History"), London, 1899, pp. 464–66.

from hairs, projects slightly beyond the anterior margin. Small gills are situated around each sucker except the first, as described by Fritz Müller.

The dorsal surface of each division bears about twelve to fifteen stout, black, sharp spines projecting upwards at right angles to the surface, and the round post margin of the last segment is fringed with a row of slender black hairs. The side lobes are short, about half as broad as long, narrowing to the subacute extremity; they are lighter in colour than the body, and bear numerous stiff hairs of varying stoutness, but all more slender than the spines on the body. The colour of the body varies from dark-brown to black, the side lobes being light-brown. The larvæ live in rapid rocky streams, and by means of their suckers cling to the stones and boulders with considerable tenacity.

EXPLANATION OF PLATE XLVI.

Fig. 1. Dorsal view; × about ten times.
Fig. 2. Ventral view; × about ten times.

Art. XXXIV.—*Results of Dredging on the Continental Shelf of New Zealand.*

By R. Murdoch and H. Suter.

[*Read before the Wellington Philosophical Society, 4th October,* 1905.]

Plates XXI–XXVII.

This article is a sequel to Mr. Hedley's paper under the same heading and in this volume. All the shells here enumerated were obtained together with those described by Mr. Hedley and the Rev. W. H. Webster.

1. **Philine constricta**, n. sp. Plate XXI, fig. 1.

Shell small, thin, convolute, imperforate, spirally grooved, auriform, slightly contracted above. Sculpture consists of shallow fine spiral grooves, leaving broader bands between them, crossed by irregularly arranged incremental lines. Colour white. Spire concave. Protoconch minute, smooth. Whorls $1\frac{1}{2}$, very rapidly increasing, the last very large, contracted below the vertex. Aperture elongately oval, acuminate above. Outer lip sharp, lowly convex, microscopically transversely striated inside; lower lip regularly rounded. Inner lip forming a broadly spread callosity upon the body, narrow on the concave oblique and twisted columella. Altitude, 5 mm.; diameter, 3 mm.

Type in the Colonial Museum, Wellington.

Obs. Two dead shells were obtained. By its distinct spiral ornamentation, the elongate form, and small size it is well characterized.

2. **Philine umbilicata**, n. sp. Plate XXI, fig. 2.

Shell small, oval, truncate above, umbilicated. Sculpture inconspicuous, distant very fine microscopical lines are crossed by irregular curved and very fine growth-lines. Colour white. Spire slightly immersed. Protoconch minute, smooth. Whorls 2, very rapidly increasing, the last truncated above, rounded at the base, narrowed and flatly convex above. Aperture elongated-oval, slightly excavated above by the body-whorl, broad and open toward the base. Outer lip thin, sharp, almost straight for the upper two-thirds, then forming a regular arch with the convex basal lip. Inner lip forming a rather broad but very thin callosity upon the body, inconspicuous on the columella, which descends with a rather sharp margin, but slightly excavated, to the basal lip. Umbilicus patulous, distinct. Altitude, 3·5 mm.; diameter, 2·25 mm.

Type in the Colonial Museum, Wellington.

Obs. Four dead shells. This species is distinguished by the almost total absence of spiral sculpture and the presence of a distinct umbilicus, which is an exception in this genus.

3. **Cylichna pygmæa**, A. Adams.

Bulla (*Cylichna*) *pygmæa*, A. Adams, Thes. Conch., vol. ii, p. 595, pl. cxxv, fig. 150, 1850; Man. Conch. (1), vol. xv, p. 319, pl. lix, fig. 9. *Cylichna atkinsoni*, T.-Woods, P.R.S. Tasm., 1876, p. 156.

One dead shell only, which agrees with specimens from Tasmania and South Australia.

4. **Cylichna thetidis**, Hedley.

Memoirs Austral. Mus., iv, part 6, pp. 395–96, fig. 111 in text, 1903.

One dead shell turned up; the specimen was identified by Mr. Hedley, who informed us that two more from New Zealand dredgings were in his possession.

5. **Cylichna simplex**, n. sp. Plate XXI, figs. 3, 4.

Shell small, subcylindrical, involute, imperforate, thin and glossy. The sculpture consists of exceedingly fine growth-striæ, with here and there faintly marked growth-periods; the axial striæ are crossed by equally fine microscopic spiral lines, in places scarcely perceptible. Colour white. Spire sunken, concave, broad and deep, with a minute dome-shaped projection arising from and closing the axial perforation. Protoconch showing as a minute globular central point. Aperture as long as the shell, narrow above, expanded and slighty effuse below. Outer lip almost straight, sharp, rounded at both ends. Inner lip spread as a thin callus over the inner wall, thickening upon the columella, which is uniformly curved and has a slightly reflected rounded margin; the fold imperceptible. Altitude, 4·38 mm.; diameter, 2·21 mm.

Type in the Colonial Museum, Wellington.

Obs. A fair number of dead shells were found. In dimensions and contour this species is near to *C. striata*, Hutt., but the very different form of the columella at once distinguishes it.

6. Tornatina pachys, Watson.

Utriculus (*Tornatina*) *pachys*, Watson, Journ. Linn. Soc. Lond., vol. xvii, p. 331, 1883; "Challenger" Reports, vol. xv, p. 660, pl. xlix, fig. 8.

A young shell, measuring 3·2 mm. by 1·6 mm., was found, which may be Watson's species, but differing from it in the slightly raised top and more distinct spiral striation. In all other characters the specimen agrees with Watson's diagnosis and figure. The differences may be due and peculiar to the neanic stage of the species.

7. Ringicula delecta, n. sp. Plate XXI, fig. 5.

Shell small, oval-globular, imperforate, with a relatively short conoidal spire, somewhat thin. The sculpture consists of fine slightly variable spirals which somewhat strengthen upon the base, and are a little wider than the grooves; there are eight to ten upon the penultimate whorl, and thirty to forty upon the last, nine to twelve in front of the aperture. These spirals are crossed by close irregular incremental striæ, which in places cut the spirals into minute gemmules, and when prominent produce a lightly costate appearance. Colour white, fresh specimens vitreous. Spire shorter than the aperture, acute, terminating in a sharp apex. Protoconch of about two whorls, the nucleus minute, slightly raised, smooth, the second turn microscopically decussate. Whorls 5, rounded, the last proportionately large, globular, and with convex base. Suture impressed, not channelled. Aperture vertical, semi-lunar, angled above, sinuated and with a very short open canal, notched at the base. Outer lip convex, straightened at the periphery, regularly arched below, sharp. Inner lip forming a well-defined callus on the body, with one or two low tubercles; columella short, vertical, stoutly callused and with two strong rounded folds, the lower of which is largest, and forms with the end of the columella a prominent rounded point. Altitude, 4·35 mm; diameter, 2·9 mm.

Type in the Colonial Museum, Wellington.

Obs. This pretty little species was represented by a fair number of dead shells amongst our dredgings. It is very distinct and rather more thin than usual in this genus. This is the first species of *Ringicula* recorded from New Zealand waters.

8. Solidula alba, Hutton.

Buccinulus albus, Hutton, Cat. Mar. Moll. N.Z., p. 51, 1873.

A few young and imperfect dead shells, which are exceedingly friable.

9. Actæon craticulatus, n. sp. Plate XXI, fig. 6.

Shell small, oval, whitish, subperforate, cancellated, with a basal fold upon the columella. Sculpture consists of well-impressed spiral grooves of rather irregular width, with interstices of nearly the same breadth, though in some specimens they are distinctly broader. This spiral sculpture is very variable. There are subequidistant axial threads cutting up the spiral furrows into oblong squares. Colour of most specimens (all dead shells) white; a few specimens only show purple coloration on the body-whorl, leaving a white band below the suture. Spire conical, acuminate, less than half the length of the shell. Protoconch paucispiral, not distinctly separated from the succeeding whorl, lightly corroded in most specimens, nucleus small. Whorls 5, the last of considerable size, slightly angled above, flatly convex, base narrowed and rounded. Suture deep, distinctly canaliculate. Aperture subvertical, elongated-pyriform, produced at the base. Outer lip sharp, very little convex, nearly straight, minutely denticulate, sharply rounded at the base. Inner lip narrow, thin; columella with a moderately large smooth plait situated at the lower third, slightly excavated above, reaching the effuse basal lip in a light curve. A small umbilical chink opposite the tooth. Altitude, 9 mm.; diameter, 4·5 mm. Aperture: length, 5·5 mm.; breadth, 2 mm.

Type in the Colonial Museum, Wellington.

Obs. About twenty specimens were obtained. The species is distinguished from *A. kirki* by the cancellated ornamentation and the smooth columella fold.

10. **Daphnella protensa**, Hutton. Plate XXI, figs. 7, 8.

Daphnella protensa, Hutton, Trans. N.Z. Inst., vol. xvii, p. 317, 1885 (from the Pliocene of Petane).

Two specimens turned up, which differ from the type by the predominating spiral sculpture and very feeble axial plications. Typically there are delicate spiral threads, but in our specimens there are distinct chords present, which are crossed by flexuous longitudinal striæ. Only the upper whorls are distinctly decussate. The protoconch, consisting of two smooth whorls, is much larger than in fossil specimens from Petane, more bulbose, and with an oblique nucleus.

This form may constitute a new subspecies, but the material at our disposal is too scanty to decide this point with certainty. A figure of this variety and of the protoconch are here given.

11. **Mangilia dictyota**, Hutton.

Clathurella dictyota, Hutton, Trans. N.Z. Inst., vol. xvii, p. 316. 1885 (from the Pliocene of Wanganui and Petane).

Two dead shells which correspond with Hutton's diagnosis; they have the same dimensions, but the anal sinus is more conspicuous and deeper. Usually recent specimens from shallow water are slightly larger.

12. **Drillia buchanani**, Hutton, subsp. **maorum**, E. A. Smith.

Surcula buchanani, subsp. *maorum*, Suter, Proc. Mal. Soc., vol. vi, No. 4, p. 200, 1905.

A few fairly well preserved dead shells were dredged. They are much smaller than the typical form, having a length of 12 mm. only, against 21 mm. Similar small examples were also collected by Mr. A. Hamilton, Director of the Colonial Museum, off Otago Heads.

Harris suggested that *P. buchanani* should be classed with *Surcula*, but its proper place seems to be under *Drillia*.

13. **Drillia**, sp.

Of this form there are two small examples, but in so poor a condition that we hesitate to describe them. The shells apparently are not adult; the sculpture approaching perhaps nearest to the Pliocene fossil *Pleurotoma gemmea*, Murdoch.*

* Trans. N.Z. Inst., vol. xxxii, p. 217, pl. xx, fig. 9, 1900.

14. **Drillia optabilis**, n. sp. Plate XXI, fig. 9.

Shell small, narrow, turriculate, last whorl shorter than the spire, clathrate, aperture pyriform, canal short. Sculpture : On the spire-whorls three spiral equidistant cords, which are crossed by longitudinal also equidistant threads, forming small beads at the intersections, and squarish interstitial depressions ; there are about twenty-one beads on a row ; on approaching the base the spirals are getting narrower than the interspace, and the beading less prominent ; upon the beak there are small irregular threads crossed obliquely by the plications of the old beaks. Colour greyish-white. Spire turriculate, not very conspicuously shouldered, longer than the last whorl. Protoconch : The outer shelly layer has scaled off and it is impossible to give a description ; the nucleus is globular and obliquely tilted. Whorls 7, narrowly angled and excavated above, sides almost straight ; base convex and narrowed to a short and anteriorly sinuated beak. Suture bimarginate, above by a minute threadlet, below by a broad and heavy cord which is obliquely irregularly plicated. Aperture pyriform, angled above, with a concave inner wall, ending in a short broad canal, which turns slightly to the left. Outer lip curved, imperfect ; the lines of growth would indicate that the sinus is situate in the excavation below the sutural cord, that it is small and moderately deep. Inner lip spread as a thin layer narrowly over the body, broader over the columella, which is first straight and then slightly twisted to the left, ending in a sharp point. Altitude, 10·7 mm. ; diameter, 3·93 mm. ; angle of spire, about 22°.

Type in the Colonial Museum, Wellington.

Obs. A single specimen of this beautifully sculptured shell was collected.

15. **Drillia (Crassispira) lævis**, Hutton.

Pleurotoma lævis, Hutton, Cat. Mar. Moll. N.Z., p. 12, 1873.

Half a dozen much broken examples of this species occur ; they are more strongly and rather less numerously plicated than the typical forms from shallower water. However, fossil specimens from the Wanganui Pliocene make a near approach to them. The angle of the spire is 30°, as in the type.

This species should be assigned to the subgenus *Crassispira*, Swainson, 1840, distinguished from *Drillia*, s. str., by the short and wide canal, the deeper sinus, paucispiral protoconch, &c.

16. **Pleurotoma (Hemipleurotoma) nodilirata**, nom. mut. Plate XXII, figs. 10, 11.

Pleurotoma tuberculata, T. W. Kirk, Trans. N.Z. Inst., vol. xiv, p. 409, 1882 (not of Gray); Hutton, Plioc. Moll. N.Z., in Macleay Mem. Vol., p. 50, pl. vi, fig. 29, 1893 (not of Gray).

The species, described from a Pliocene specimen, requires a new name, that proposed by Kirk being preoccupied by Gray, and the above is offered. Kirk's description being rather scanty, the following complement is now given, compiled from recent specimens.

Shell fusiform, biconical, with nodulous keeled whorls, pyriform aperture, and short open canal. Sculpture: Last whorl with about sixteen tubercles on the keel, and a similar number of spiral cords below, the upper six of which are widely spaced and narrower than the interspaces; those upon the base and canal are smaller and crowded. Above the aperture is a single chord, which persists on the whorl above, but disappears in the suture of the next whorl. Monilo-spiral threadlets adorn the sinus area, also the tubercles. All the upper whorls, except the protoconch, have tubercles on the keel, and there is a row of small nodules below the suture. The axial sculpture consists of fine rather irregular incremental lines, which, however, become more prominent on the lower whorls, connecting the small tubercles below the suture with the larger ones on the keel. Colour light-cream. Spire conical, about as long as the body-whorl. Protoconch consisting of one and a half to two whorls, nucleus obtuse, smooth, polished, the succeeding volution with minute spiral striæ. Whorls 7, slowly and regularly increasing, with a strong carina below the middle, excavated above and straight below the keel; base convex, ending in a slightly twisted rather short beak. Suture deep and margined below with a row of small elongate gemmules. Aperture pyriform, rather narrow, angular above, terminating in a short open truncated canal, which has a slight turn to the right. Outer lip sharp, strongly angled, and with a well-pronounced rounded sinus at the keel, contracted towards the base. Inner lip forming a very thin obliquely finely striated layer on the body and columella, the latter nearly straight, slightly sinuated and pointed below. Altitude, 19·6 mm.; diameter, 8·5 mm.; angle of spire, 42°.

Type of *P. tuberculata*, Kirk, in the Colonial Museum, Wellington.

Obs. No perfect or live specimens were gathered, only a small number of more or less damaged very fragile shells.

Of this species a smaller form occurs, but similarly sculptured, and it seems scarcely worth a varietal name. It is also found in the Wanganui blue clay of Pliocene age. The recent specimens are imperfect in outer lip and spire, but with the aid of fossil individuals the accompanying sketch (fig. 11) is derived. The larger type specimens in the Colonial Museum are from the Petane Pliocene; in these, as also in the smaller form, the tubercles are less strong and more numerous than in recent examples.

17. **Pleurotoma (Hemipleurotoma) alticincta**, n. sp. Plate XXII, figs. 12, 13.

Shell small, turriculate, subcylindrical, with a long spire, deeply sulcate whorls, an oblong aperture which is slightly shorter than the spire, and a short canal. Sculpture: On the upper spire-whorls a few minute spiral striæ, the next with four distinct cinguli, on the succeeding a minute fifth spiral arises at the suture, which on the penultimate strengthens and about equals the adjoining revolving ribs; the cinguli are strong, rounded and adorned with minute spiral threadlets, absent in the grooves; the latter are deep, somewhat square-cut, and narrower than the ribs; the last whorl with ten ribs and a number of minute threadlets upon the back of the canal, added to which are the oblique lines of old beaks; grooves and ribs about equal, but the former sometimes broader as they proceed anteriorly. The longitudinal growth-striæ are minute, slightly irregular in strength, and giving in places (usually upon the upper whorls of the spire) a slightly clathrate appearance. Colour: There is only one young specimen that has a somewhat fresh appearance, it is light horn-coloured; all the others are greyish-white. Spire long, gradate, turriculate, with an obtuse rounded apex. Protoconch of about two convex turns, slopingly shouldered, with minute spirals the precursors of the adult sculpture; nucleus central, depressed-globular, smooth. Whorls 7, flattened, strongly shouldered at the suture, first slowly then more rapidly increasing, the last a little longer than the spire. Suture deep, margined above on the lower whorls. Aperture elongate, somewhat narrow, slightly contracted in front and forming a short open canal, which is truncated and slightly sinuate at the base, bent backward and a little to the left. Outer lip slightly thickened, descending with a light downward sweep, crenulate on the margin; the sinus indistinct, situated on the uppermost cingulum. Inner lip forming a broad callus through which on the body the three cinguli appear as folds, with a distinct edge, which is slightly raised, connected above with the outer lip; columella excavated in the middle, drawn out to a point on approaching the anterior beak. Altitude, 15·7 mm.; diameter, 5·75 mm.

Type in the Colonial Museum, Wellington.

Obs. This species is in its sculpture nearly allied to *P. septemlirata* and *trilirata*, Harris, from the Eocene of Australia. Three perfect specimens, one not quite adult, and a number of fragments, were obtained, all dead shells.

18. **Pleurotoma (Leucosyrinx) augusta**, n. sp. Plate XXII, figs. 14–17.

Shell fusiform, slender, fragile, spire and body-whorl of about the same length, whorls with a spiral keel bearing small nodules, canal long. Sculpture: The whorls are strongly keeled at the periphery and with a row of gemmules set slightly oblique thereon, on the last whorl there is a lower smooth keel present; a few inconspicuous spiral striæ are on the area between the keels and on the anterior extremity. The axial sculpture consists of minute and irregular growth-lines only. Colour pure-white, slightly shining. Spire pagodiform, elongated. Protoconch smooth and shining, consisting of about two turns; the nucleus is slightly tilted, and with a distinctly marked smooth carina, which is much strengthened on the succeeding whorl. Whorls 7, regularly and rather slowly increasing, the last biangulate, concave below the keels and produced into a rather long narrow and truncated beak. Suture deep, minutely bimarginate. Aperture angularly ovate, broadly angled above, contracted below and terminating in a rather long open canal, which is somewhat turned to the left. The outer lip has its margin not quite perfect, which perhaps lends to the scarcely fully adult appearance of the shell; it is biangled and concave above, between, and below the angles; sinus broad and moderately deep, extending almost from the suture to the keel. The inner lip spreads as a very thin narrow callus over the concave body and the columella, which is nearly straight and slightly twisted, ending in a fine point on the left margin of the canal. Altitude, 10·32 mm.; diameter, 3·9 mm.; angle of spire, 28°.

Type in the Colonial Museum, Wellington.

Obs. Only two specimens of this graceful little shell were found. It is allied to *Pleurotoma alta*, Harris (= *pagoda*, Hutton, *non* Reeve)*, from which, however, it may be readily distinguished by the gemmules on the keel and the distinct carina on the protoconch, both of which characters are absent in the Tertiary fossil.

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* Cat. Tert. Moll. Brit. Mus., Australasia, part i, p. 45.

19. **Pleurotoma (Leucosyrinx) eremita**, n. sp. Plate XXII, figs. 18, 19.

Shell small, fusiform, fragile, with shouldered whorls, the body-whorl but slightly shorter than the spire, and a rather short open canal. The sculpture consists of longitudinal and spiral threads and riblets, the former inclined slightly backward; they number about fifteen on the penultimate whorl and are obsolete above the angle, absent upon the greater part of the last whorl. The spirals consist of five minute threads on the slope above the angle; beneath the latter there are four much stronger riblets, forming gemmules at the intersections of the longitudinals; the last whorl with about twenty-three spirals, those upon the base and neck more widely spaced, but equally slender as those on the shoulder. Colour light-cream. Spire turriculate-conical, with a blunt apex. Protoconch slightly bulbose, with about two smooth whorls, nucleus globular. Whorls 5, angled at the periphery, straight above, slightly convex below; base convex, then contracted and ending in a short distally rounded beak. Suture deep. Aperture pyriform, broadly angled above, ending in a rather short almost straight canal, slightly turned to the left. Outer lip imperfect, convex above, contracted near the base; it is evident from the growth-lines that the sinus is broad, rounded, and moderately deep, extending almost from the suture to the keel. Inner lip forming a thin and narrow callosity on the almost straight columella, which is slightly twisted at the base. Altitude, 5·8 mm.; diameter, 2·42 mm.

Type in the Colonial Museum, Wellington.

Obs. Of this species there is but a single and not fully adult example, a dead shell, which appears to be allied to *P. ischna*, Watson, which was obtained in 700 fathoms north-east from New Zealand. Our species is smaller, less slender, with fewer whorls, and has much more numerous and stronger spiral riblets, especially round the periphery of the whorls. The situation of the sinus seems to be the same in both species.

20. **Ancilla mucronta**, Sowerby.

Spec. Conch., part i, p. 8, figs. 47, 48, 1830.

Two dead shells with a very distinct mucronate apex.

21. **Ancilla bicolor**, Gray.

Jukes' Voy. "Fly," vol. ii, p. 357, pl. i, fig. 4, 1847.

A fair number of young specimens, only one of them alive.

22. **Fulguraria (Alcithoe) gracilis**, Swainson.

Exotic Conch., pl. xlii, 1821.

One very good shell was obtained; altitude, 65 mm.

23. **Fulguraria (Alcithoe) hedleyi**, n. sp. Plate XXIII, figs. 20, 21.

Shell elongato-fusiform, spire rather long, acuminate, costate, body-whorl smooth, with fine longitudinal zigzag markings, columella with four plaits. Sculpture : The protoconch has one or two spiral threads, the following whorls of the spire are distantly longitudinally costate, the costæ extending over the lower two-thirds of each whorl, ten on a volution ; a few costæ are situated on the body above the aperture, but the remainder is smooth ; growth-lines are visible on all the whorls, more distinct and close together on the last whorl. With a lens a number of spiral lines may be distinguished below the shoulder of the whorls. Colour : No live specimens having been obtained, it is only possible to guess the colour of the shell, which is most likely light-fulvous ; fine longitudinal brown zigzag lines ornament all the whorls, except the protoconch. The spire is much shorter than the aperture, conical, acuminate but obtuse. Protoconch (fig. 21) consists of two slightly bulbous whorls ; the nucleus is slightly lateral, smooth ; the second whorl has one or two spiral threads. Whorls 7, shouldered, first slowly then rapidly increasing in height. Suture distinct but not impressed, retrocurrent on reaching the aperture. Aperture long and narrow, slightly canaliculated at the upper angle, very slightly narrowed at the base, where it is broadly truncated and sinuated. Outer lip forming a very light curve, nearly straight, thickened and rounded above, thinner near the base, smooth, not expanded. Inner lip thin, shining, broadly expanded on the body and with a few longitudinal striæ, narrower on the columella, which is very slightly excavated near the middle, with four almost equidistant and very oblique strong plaits, all of nearly equal size ; columella narrowed into a sharply rounded beak, which extends beyond the basal margin of the outer lip. Altitude, 61 mm. ; diameter, 18 mm. Aperture : length, 39 mm. ; breadth, 7 mm. Angle of spire, 32°.

Type in the Colonial Museum, Wellington.

Obs. Two specimens, only one adult, were obtained, and they had evidently been buried in the mud for a considerable time. This species is nearly allied to *F. gracilis*, which attains about the same length, but is much more ovoid, has more numerous costæ on the whorls, and a much wider aperture. Our species has the body-whorl subcylindrical, the zigzag markings much finer and not crowded.

The species is named in honour of Mr. Charles Hedley, of the Australian Museum, Sydney, the originator and leader of our dredging expedition.

24. **Vulpecula (Pusia) biconica**, n. sp. Plate XXIII, fig. 22.

Shell very small, biconical, imperforate, a row of nodules on the lower whorls, suture margined, aperture narrow, with four columellar plaits. Sculpture: On the third to fifth whorls there are oblique longitudinal costæ, produced into nodules on the angle of the whorls, below the suture a broad rim, under the nodules of the last whorl two very fine spiral threads and several more towards the base. Colour white, with fulvous on the nodules of the first half of the last whorl, continued in broad zigzag lines down to the base on the second half. Spire conoidal, about half the length of the shell, obtuse. Protoconch formed by one and a half whorls only, papillate, smooth, glossy; nucleus slightly excentric, broadly convex. Whorls 5, rather rapidly increasing, shouldered with about fourteen short nodulous ribs, disappearing shortly before reaching the outer lip; base regularly attenuated. Suture distinct, slightly impressed, broadly margined below. Aperture somewhat oblique, narrow, with subparallel sides, slightly channelled above, produced at the base into a very short broad convexly truncated canal. Outer lip damaged in both specimens, thin. Inner lip forming a white-enamel layer of moderate width on the concave body and on the columella, which is a little oblique and bears four plaits, the first and second nearly horizontal, the following two oblique; they slightly increase in size from the base upwards. Altitude, 5 mm.; diameter, 2·8 mm. Aperture: length, 2·5 mm.; breadth, 0·6 mm.

Type in the Colonial Museum, Wellington.

Obs. A small number of this beautiful shell were obtained. It is much smaller than *V. rubiginosa* and *planata*, and at once distinguished by its nodulous ornamentation and the colour-markings, recalling *Alcithoe*.

25. **Marginella fusula**, n. sp. Plate XXIII, figs. 23, 24.

Shell small, rather thin, oval-conic, smooth and glossy, and with a much produced spire. Sculpture consisting of low rounded growth-periods, numerous and irregular, usually more marked on the last half-volution. Colour white, or with a faint yellow tinge; occasionally some indistinct brown markings which form two spots on the outer lip, and seem to indicate the presence of two brown spiral bands on the body-whorl in fresh specimens. Spire produced, a little shorter than the aperture, conical, with an obtuse rounded apex. Protoconch paucispiral, smooth, rounded, nucleus depressed. Whorls 4, flatly convex, the last produced and narrowed anteriorly, with a slight but distinct swelling which proceeds as a pad from opposite the posterior plait and sweeps out and forwards. Suture distinct, lightly impressed. Aperture elongate, narrow, subchannelled above, broadly rounded at the base. Outer lip very slightly reflected and thickened, smooth inside, a little retrocurrent at its insertion. Inner lip forming a narrow callus upon the oblique almost straight body; the columella subvertical with four evenly spaced rather thin plaits, the superior short and almost transverse, the next sloping, but less oblique than the succeeding two, the lower of which is a little twisted and margins the very short open canal. Altitude, 6·87 mm.; diameter, 3·11 mm.

Type in the Colonial Museum, Wellington.

Obs. A few dead and mostly damaged specimens. It is quite different from all the other hitherto known New Zealand species. From the nearly allied *M. allporti*, T.-Woods, it is distinguished by the larger size and more slender form, as well as by the absence of denticles on the inner margin of the outer lip, but the indication of brown spiral bands connects it with that species.

26. Marginella hebescens, n. sp. Plate XXIII, figs. 25, 26.

Shell small, moderately solid, suboval, smooth and polished. The sculpture consists of irregular minute and smooth growth-periods. Colour white or pale-creamy, pellucid when fresh. Spire elevated and with a blunt apex, about one-third of the total length of the shell. Protoconch paucispiral, smooth, broadly rounded, with a flat small nucleus. Whorls 4, lightly rounded, the last narrowed at the base and with a distinct swelling curving out and forward from the columella, base convex. Suture rather broadly impressed and submargined below. Aperture longitudinal, narrow, margins subparallel, with an indistinct channel above. Outer lip slightly reflected and thickened, inside smooth, a little retrocurrent at its insertion and with a small distinct sinus. Inner lip narrow on the oblique somewhat convex body; columella slightly oblique, nearly straight, with four equidistant stout plaits, the first transverse, the following two oblique, and the last subvertical and margining the short broad and anteriorly rounded canal. Altitude, 3·8 mm.; diameter, 2·07 mm.

Type in the Colonial Museum, Wellington.

Obs. A number of dead shells were obtained. This species also is allied to *M. allporti*, T.-Woods, but is distinguished from it by the shorter spire and longer aperture, the bluntly rounded apex, the stronger columella-plaits, and absence of all colour-markings.

27. **Cryptospira (Gibberula) ficula**, n. sp. Plate XXIV, fig. 27.

Shell very small, subpyriform, smooth and polished, with but very slightly raised spire. Sculpture: Some examples show minute growth-periods, more distinct on approaching the lip. Colour whitish, vitreous in fresh shells. Spire very little elevated, broadly rounded. Protoconch of about one and a half whorls, smooth, flattened, the nucleus but slightly raised. Whorls 3 to 3½, those of the spire very low and narrow, the last occupying nearly the whole of the shell, rounded and lightly ventricose above, narrowed toward the base; basal limb large and callous, corresponding to the growth-periods of the notch, bordered by a minute ridge. Suture minute but distinct. Aperture very narrow above, channelled, slightly broader towards the base, where it is deeply notched. Outer lip very little thickened, almost straight, retrocurrent in a half-circle towards the suture, rounded off on the base; in adult specimens the inner margin of the lip minutely transversely denticulate. Inner lip thin and narrow on the lightly convex body, broadening and thickening on the slightly excavated columella, which bears three small but distinct plaits; they are oblique, equidistant, and the last extends to the rounded basal point of the columella; two or three minute denticles are sometimes distinctly visible on the wall of the body, situate above the others. Altitude, 3·45 mm.; diameter, 2·17 mm.

Type in the Colonial Museum, Wellington.

Obs. A number of dead shells were collected. Its nearest ally is *Marginella strangei*, Angas, from Australia and Tasmania, which also belongs to the genus *Cryptospira*: this species is a little larger (altitude 5 mm.), with the spire considerably more produced and the upper columella-plaits more distinctly exserted.

28. **Fusus spiralis**, A. Adams.

Proc. Zool. Soc., 1855, p. 221, publ. 1856.

A fine beautifully coloured and adult specimen, inhabited by a hermit-crab, was found, which was presented to the Auckland Museum. Besides this, fragments of dead young shells turned up.

29. **Murex (Poirieria) zelandicus**, Quoy and Gaimard.

Voy. Astrol., Zool., vol. ii, p. 529, pl. xxxvi, figs. 5–7, 1833.

Two young dead shells.

30. **Megalatractus maximus**, Tryon. Plate XXIV, fig. 28.

Man. Conch. (1), vol. iii, p. 135, pl. liv, fig. 355, 1881; Hedley, Memoirs Austral. Mus., vol. iv, part 6, p. 374, pl. xxxviii.

Two protoconchs of what we take to be this species were obtained. They certainly do not belong to *S. dilatata*, Q. and G., and as *M. maximus* turned up alive from 30 fathoms near Channel Island, as will be recorded in another paper, there seems to be no reason to doubt the identity of the species. In the specimen from Channel Island, part of the protoconch is preserved, and it is very much like these specimens from 110 fathoms. On the whorl succeeding the protoconch there are ten nodules; the canal is very long, narrow, and bent to the right. As most adult specimens are, as it seems, more or less decollate, we give here a sketch of the more perfect protoconch. It is pupoid, polygyrate, consisting of four convex whorls with spiral riblets, crossed by incremental lines; nucleus central, small, slightly raised. Most of the outer layer has peeled off, and only traces of the sculpture are left.

31. **Siphonalia nodosa**, Martyn.

Univ. Conch., Buccinum, vol. i, fig. 5, 1784.

A fair number of dead young shells, all very fragile.

32. **Columbella choava**, Reeve.

Conch. Icon., spec. 239, 1858.

One dead specimen, greyish-white, which is smaller and more slender than typical examples, but otherwise there is nothing to separate it from Reeve's species. Altitude, 3·8 mm.; diameter, 1·6 mm.

33. **Turritella pagoda**, Reeve.

Conch. Icon., spec. 60, 1849.

A few dead young and imperfect specimens, which agree with examples from the Wanganui Pliocene.

34. **Turritella fulminata**, Hutton.

Cat. Mar. Moll. N.Z., p. 29, 1873.

A few young dead shells, which have lost the characteristic colour-markings.

35. **Turritella carlottæ**, Watson.

Journ. Linn. Soc. Lond., vol. xv, p. 222, 1880 (= *vittata*, Hutt., *non* Lamk.).

One partly broken shell only.

36. **Diala subcarinata**, n. sp. Plate XXIV, fig. 29.

Shell minute, subulate, smooth, narrowly perforate. Sculpture: The longitudinals consist of minute growth-striæ, with here and there irregular marks of growth-periods, subcostate in places. Colour porcellaneous-white. Spire high, slender, and tapering. Protoconch consists of about two smooth rounded whorls, the second with a slightly swollen aspect, the nucleus oblique. Whorls 7, slightly rounded; the antipenultimate whorl is indistinctly feebly bicarinate; this is better defined upon the next whorl, especially the superior angle which forms the subtabular suturial shelf; upon the last four or five feeble carinæ, three of which are above the aperture, the base rounded. Suture deep. Aperture vertical, subtriangular. Outer lip sharp, regularly curved, effuse and angled at the junction with the basal extension of the columella, producing a small spout-like canal. Inner lip forming a narrow thin callosity on the pillar, which is subvertical and slightly sinuated; a thin callus extends above over the body to the outer lip. Umbilicus very narrow, open. Altitude, 2·9 mm.; diameter, 1·04 mm.

Type in the Colonial Museum, Wellington.

Obs. A single dead shell was found, which adds a genus to the New Zealand fauna.

37. **Natica zelandica**, Quoy and Gaimard.

Voy. Astrol., Zool., vol. ii, p. 237, pl. lxvi, figs. 11, 12, 1832.

A young dead shell which has lost the outer calcareous layer.

38. **Natica australis**, Hutton.

Journ. de Conch., vol. xxvi, p. 23, 1878.

A good number of specimens were found, all dead shells, white, porcellaneous.

39. **Calyptræa scutum**, Lesson.

Voy. "Coquille," Zool., vol. ii, p. 395, 1830.

A few young dead shells.

40. **Omalaxis amœna**, n. sp. Plate XXIV, figs. 30–32.

Shell small, discoidal, bicarinate, beautifully sculptured, sides straight but oblique, umbilicus wide, carinated, perspective. Sculpture: Upper side with a beaded cord on each side of the suture, the outer one being more prominent; between them are three fine elevated spiral threads, the whole crossed by numerous oblique elevated radiating ridges, with equal interspaces, which continue over the periphery to the basal cord; on the periphery is a third beaded and conspicuous cord, which is buried in the suture; still another marginates the base, and between them are three small spiral ridges. Between the basal and umbilical ribs is a small beaded spiral, the whole reticulated by somewhat irregular distant radiate ribs, interstices having now and again one or more fine ridges; the umbilical rib distinctly beaded. Colour white. Spire flat. Protoconch dextral, smooth, consisting of one and a half convex whorls. Whorls $3\frac{1}{2}$, flattened, regularly increasing, with the sides almost straight, subquadrate in section, the base somewhat excavated. Suture slightly channelled. Aperture subquadrate. Outer lip sharp, with two angles above and one below. Columella short, concave. Umbilicus large, scalar, with the sides inclined. Operculum unknown. Diameter: maximum, 3 mm.; minimum, 2·5 mm. Altitude, 1 mm.

Type in the Colonial Museum, Wellington.

Obs. One dead shell only. This very interesting addition to our fauna is almost identical with *Discohelix retifera*, Dall., from the Pliocene of Florida. The operculum of our species being unknown, we place it for the present in the genus *Omalaxis*, Deshayes. A similar form, *O. meridionalis*, dredged in Port Stephens, but not so elaborately sculptured, has been described and figured by Mr. C. Hedley in Memoirs Austral. Museum, iv, part 6, 1903, p. 351.

41. **Aclis semireticulata**, n. sp. Plate XXIV, figs. 33, 34.

Shell small, subulate with a rounded base, subrimate, longitudinally costate and with a spiral thread on the last whorl. Sculpture longitudinal and spiral; the latter consists of some minute striæ upon the base, occasionally extending above the periphery, and usually absent upon the spire. The longitudinals form small rounded costations, obsolete or absent upon the base, and generally very variable, some fairly uniform throughout, others feeble on the last whorl, and others again more or less obsolete on all whorls. Colour light-horny, hyaline. Epidermis very thin, glossy, membranaceous, present on a few specimens only. Spire conical, longer than the body-whorl, with a blunt apex. Protoconch formed by about two smooth rounded and vitreous volutions. Whorls 6, regularly increasing, rounded, and with a convex slightly produced base. Suture deep, margined above by a minute threadlet which strengthens upon the later whorls, and continuing forms a distinct thread below the periphery upon the body-whorl. Aperture broadly ovate. Outer lip regularly rounded, slightly varicose, the varix usually set a little back from the edge. Inner lip forming a small reflected callus upon the body, extending to the outer margin, and upon the excavated columella, which is mostly a little produced below, forming an angulation of the aperture. Umbilical chink very narrow or obsolete. Altitude, 3·3 mm.; diameter, 1·7 mm.

Type in the Colonial Museum, Wellington.

Obs. A number of specimens, none with the animal. This species may represent the *Aclis* (*Rissopsis*) *hyalina*, Hutton,* the type of which seems to be lost. Hutton's species is unfigured, and the description scarcely sufficiently full to identify it with certainty. In any case *Aclis hyalina*, Hutt., cannot stand, the name being preoccupied by Watson.

42. Scala zelebori, Dunker.

Verhandl. Zool. Bot. Gesellsch., Wien, vol. xvi, 1866, p. 912.

Two damaged young shells.

43. Scala levifoliata, n. sp. Plate XXV, figs. 35, 36.

Shell small, turreted, imperforate, many-whorled, longitudinally laminated, with a few spiral ribs and small suborbicular aperture. Sculpture: Spire-whorls bicarinate, the slope uniform from the suture to the upper carina, situate on the lower half of the whorls; the lower carina is less conspicuous and close to the suture; the last whorl is tricarinate with the basal keel microscopically granulate, and below this is a well-marked furrow bounded by a small concentric rib, which margins the columella; on the lower part of the shoulder two indistinct spiral threads, more obscure on the upper whorls. The longitudinal ornamentation consists of obliquely advancing, close, delicate, undulating, and sharp laminations, extending over the suture, and terminating at the basal carina. Colour greyish-white. Spire elongate, turreted, sharply pointed. Protoconch consisting of about two small rounded whorls, the nucleus with the initial half-turn smooth, the other half longitudinally delicately ribbed, which is followed on the second whorl by the sharp laminations of the ephebic stage. Whorls 10, regularly increasing, with straight sides above the keel, slightly concave between the encircling ribs. Suture deep and channelled, which character is hidden to a great extent by the longitudinal laminations extending over it. Aperture ovato-orbicular, angled above. Outer and basal lip rounded, slightly effuse, sharp, and with flexuous projections corresponding to the spiral keels; columella concave, very little callous, terminating at the base in a minute sharp point. Altitude, 5·7 mm.; diameter, 1·62 mm.

Type in the Colonial Museum, Wellington.

Obs. A most graceful little shell, of which there are but two dead specimens, one not full-grown. We are informed by Mr. C. Hedley that he is describing a nearly allied form from Australian waters.

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* New Zeal. Journ. Sci., vol. ii, 1884, p. 173; Proc. Linn. Soc. N.S.W., vol. ix, 1885, p. 935.

44. **Odostomia (s. str.) marginata**, n. sp. Plate XXV, fig. 37.

Shell small, ovate, white and shining, almost smooth, with a margined suture and angled body-whorl. Sculpture consists of distinct flexuous growth-lines, irregularly spaced, and with much finer incremental striæ between them; with a magnifying-power of about thirty diameters distant fine spiral striation can be made out. Colour white, shining, porcellaneous. Spire elevated, conical, about the same length as the last whorl. Protoconch consisting of about two smooth whorls, the nucleus heterostrophe, tilted. Whorls 6, flatly convex, the last angled at the periphery; base convex. Suture impressed, distinctly margined below. Aperture vertical, pyriform, angled above, rounded and slightly effuse below; peritreme discontinuous. Outer lip sharp, flatly convex, sharply rounded at the base. Columella with a very distinct tooth just below the junction with the body-whorl, concave below. Umbilicus represented by a distinct chink. Operculum unknown. Altitude, 4·5 mm.; diameter, 2·3 mm.

Type in the Colonial Museum, Wellington.

Obs. One adult and a few young shells, all dead. From our nearly allied *O. angasi*, *proxima*, and *vestalis* it may at once be distinguished by the distinct margination of the suture and the angled last whorl.

45. **Eulimella levilirata**, n. sp. Plate XXV, fig. 38.

Shell small, subulate, imperforate, many-whorled. Sculpture consisting of microscopic fine close and linear spiral grooves, crossed by very fine unequally spaced growth-lines. Colour white, glossy. Spire long and subulate. Protoconch smooth, with a heterostrophe, minute rounded and lateral nucleus. Whorls 7, slowly and regularly increasing; sides flatly convex, base rounded. Suture well impressed and distinct. Aperture in our only specimen imperfect, very likely subquadrate, broadly angled above. Outer lip partly broken off, sharp, convex. Inner lip forming a thin layer on the body, more callous on the straight rounded columella; basal part of peritreme broken off. Altitude, 6 mm.; diameter, 1·4 mm.

Type in the Colonial Museum, Wellington.

Obs. One dead shell only. Distinguished from the other two New Zealand species, *deplexa* and *cœna*, by the presence of spiral sculpture.

46. **Pyramidella (Syrnola) tenuiplicata**, n. sp. Plate XXV, fig. 39.

Shell minute, subulate, imperforate, white and porcellaneous, with a long spire and pointed apex. Sculpture consists of some microscopic irregular spiral striæ. Colour white, shining. Spire much longer than the body-whorl, slender and tapering. Protoconch consists of about two smooth rounded whorls, with the nucleus heterostrophe. Whorls 7, regularly increasing, lightly convex, body-whorl with a minute thread-like carina only noticeable in front of the aperture ; base rounded. Suture channelled. Aperture ovato-quadrate, vertical. Outer lip sharp, curved. Inner lip spread over the straight stoutish columella, which is reflected ; the columellar twist producing an indistinct fold ; anteriorly the lip is sharp, produced, and somewhat flattened. Altitude, 3·21 mm. ; diameter, 0·82 mm.

Type in the Colonial Museum, Wellington.

Obs. A single dead specimen, not in very good condition. It is the first record of the genus for New Zealand, *Pyramidella rosea*, Hutton, having been transferred to the genus *Columbella.*

47. **Eulima vegrandis**, n. sp. Plate XXV, figs. 40, 41.

Shell small, subulate, imperforate, straight, smooth and glossy. Sculpture absent, except an occasional interrupted varix. Colour white, porcellaneous. Spire straight, many-whorled, narrowly elevated, terminating in a sharp and slender apex. Protoconch of about two smooth whorls, very slightly curved from the axis of the shell, nucleus minute, rounded. Whorls 11, with straight sides, the last less than half the total length, indistinctly angled at the periphery ; base convex. Suture linear, on the lower whorls with a minutely submarginate appearance. Aperture pyriform, angled above, slightly oblique, rounded and a little effuse at the base. Outer lip lightly curved and thickened, feebly sinuated below the insertion. Inner lip spread narrowly as a distinct callus from the outer lip over the body and the slightly excavated columella, reflected and united with the effuse lower lip. Altitude, 6·9 mm. ; diameter, 1·9 mm.

Type in the Colonial Museum, Wellington.

Obs. Only one dead shell.

48. **Eulima infrapatula**, n. sp. Plate XXV, fig. 42.

Shell small, subulate, imperforate, broadened at the base which is distinctly angulate, tapering to a sharp slender apex which is slightly curved ; thin, smooth, and glossy. Sculpture consists of minute spiral incisions, scarcely noticeable or absent except upon the last whorl. Colour white, glossy. Spire narrowly conical, tapering rapidly to a subacicular apex which is oblique and somewhat distorted. Protoconch formed by a few smooth convex whorls, nucleus minute, rounded.

Whorls 9, lightly convex and contracted at the suture, the first four whorls more rounded than the others; varices few, interrupted, irregularly disposed and not well marked; base rounded. Suture very distinct, impressed. Aperture subvertical, rather large, obliquely quadrate, broadly angled above, flatly expanded at the base. Outer lip not much strengthened, but slightly curved and forming a broad rounded angle at the junction with the basal lip. Inner lip forming a very thin narrow callus on the body, more prominent on the stout columella, which is nearly straight, rounded on joining the basal lip, both being distinctly everted. Altitude, 5·04 mm.; diameter, 2·11 mm.

Type in the Colonial Museum, Wellington.

Obs. One dead shell only. This species is allied to *E. munita*, Hedley,* from which it may be distinguished by its smaller size, fewer whorls, the less prominent varices, and more feeble sculpture.

49. **Eulima (Mucronalia) bulbula**, n. sp. Plate XXV, figs. 43, 44.

Shell small, subulate, imperforate, white, smooth, polished Sculpture consists solely of the mostly discontinuous slightly marked varices on some of the whorls. Colour white, shining, porcellaneous. Spire long, subulate, straight. Protoconch mucronate, the nucleus small, rounded, the second whorl relatively much enlarged, bulbous; all smooth. Whorls 10, straight, regularly increasing, the last much higher in proportion and slightly angled round the centre. Suture distinct, not impressed, irregularly indented on the lower part of the shell. Aperture small, vertical, pyriform, regularly arched below. Outer lip sharp, very slightly convex. Inner lip forming a light callosity on the oblique columella and body, rounded off at the base toward the outer lip. Altitude, 13 mm.; diameter, 3 mm. Aperture: length, 3 mm.; breadth, 1·5 mm.

Type in the Colonial Museum, Wellington.

Obs. Two dead shells were obtained, one only adult. Mr. C. Hedley says that the mucronate tip of this species somewhat recalls *E. coxi*, Pilsbry.

50. **Minolia textilis**, n. sp. Plate XXVI, figs. 45, 46.

Shell small, conoidal, widely umbilicate, fragile, exquisitely sculptured. Sculpture: There are numerous radiate sharp riblets at regular intervals, the interspaces about twice the

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* Memoirs Austral. Museum, vol. iv, part 6, 1903, pp. 358–59, fig. 81 in text.

breadth of the costæ, crossing over broad rounded spiral cords. On the third whorl there are three spirals, which are supplemented on the following whorl by a faint thread below the suture, and one between the first and second cord; on the last whorl there are two rather inconspicuous spiral threads below the suture, followed to the periphery by five strong spiral cords, the last three more prominent than the others; on the base there are five narrow equal and close-set spiral riblets, and the umbilicus is margined by a stout beaded ridge. All the spiral cords are strongly and sharply beaded by the longitudinal sculpture. Colour greyish-white. Spire conoidal, with a rounded apex. Nucleus globular, small, smooth, consisting of one whorl; the succeeding volutions show already distinct radiate riblets and spiral threads. Whorls 4½, tabulate above, flatly convex below the angulation of the shoulder; base slightly convex. Suture canaliculate. Aperture subcircular, angled above, white, not nacreous inside. Outer lip sharp, convex, margined by denticles on the outside, produced by the spiral ridges. Inner lip spread as a thin callosity over the penultimate whorl and connecting the margins; columella regularly arched, sharp. Umbilicus wide, scalar, margined by a strong beaded cord followed by two spiral ridges, beaded by longitudinal riblets. Diameter: maximum, 4·3 mm.; minimum, 3·5 mm. Altitude, 3·8 mm.

Type in the Colonial Museum, Wellington.

Obs. A few dead shells only. The shell used for description and the figures is no doubt not adult, as was evidenced by fragments of a larger shell of the same species. The genus has not been recorded from New Zealand before.

51. **Minolia plicatula**, n. sp. Plate XXVI, figs. 47–49.

Shell small, orbicular, widely umbilicate, thin and fragile, whitish with radiate purple streaks, longitudinally plicate above, and spirally ribbed. Sculpture: There are rather distant oblique radiate plications extending on the body-whorl to the periphery only; these as well as the interspaces are very finely longitudinally striate. On approaching the umbilicus equidistant straight broad and flat riblets are formed, slightly beading the revolving cords. The penultimate whorl has two spiral ridges close together, flatly beaded by the radiate plications, and two some distance down towards the suture. On the last whorl are two spiral cords, somewhat removed from the suture, followed by a smooth interstice and three spiral ridges with grooves of their own width between them; five narrower cords follow from the periphery to the umbilicus, the grooves between which are first narrow, then getting broader; there is a double beaded ridge margining the umbilicus. Colour whitish with irregular radiate zigzag bands of purple. Spire low, with a blunt apex. Nucleus smooth, rather large, depressed-globular, yellowish, consisting of one whorl. Whorls 3½, shouldered, convex at the periphery; base flatly convex. Suture subcanaliculate. Aperture subcircular, very little excavated above, the margins approaching and nearly meeting, slightly nacreous within. Outer lip sharp, convex. Inner lip forming a very thin layer over the penultimate whorl; columella regularly arched, slightly reflexed, produced at the base on joining the carina of the umbilicus. Umbilicus wide, carinate, perspective, with spiral ridges and longitudinal plications on the last whorl. Diameter: maximum, 4·5 mm.; minimum, 3·8 mm. Altitude, 3 mm.

Type in the Colonial Museum, Wellington.

Obs. A few dead and mostly young shells. As type we selected a specimen obtained by Captain J. Bollons by dredging in 37 fathoms off Cuvier Island, as it is in better condition than any of those from 110 fathoms. This species is easily separated from the foregoing species by the less elaborate sculpture alone.

52. Monilea egena, Gould.

Proc. Boston Soc. Nat. Hist., vol. iii, 1849, p. 84.

One dead and imperfect shell.

53. Cirsonella granum, n. sp. Plate XXVII, figs. 50, 51.

Shell minute, turbinate, umbilicate, smooth and glossy. Sculpture absent except for the microscopic growth-striæ. Colour white, one young and apparently fresh specimen vitreous. Spire conoidal, small, a little less than the total height. Nucleus consists of one whorl, which is smooth and rounded. Whorls 4, much rounded, the last proportionately large; base convex. Suture deep. Aperture subcircular, broadly angled above, but little excavated by the body. Outer lip sharp, forming a half-circle with the basal lip. Inner lip spread as a thin layer upon the convex body, more thickened upon the concave and reflected columella. Umbilicus with its area small and with a somewhat sharply defined margin, the perforation narrow. Altitude, 1·75 mm.; diameter, 1·75 mm.

Type in the Colonial Museum, Wellington.

Obs. A few dead shells were gathered. It is a much smaller shell than *C.* (?) *neozelanica*, Murdoch,* more globular, with the aperture more circular, and better and differently defined umbilical area.

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* Proc. Mal. Soc., vol. iii, 1899, p. 320, pl. xvi, figs. 2–6.

54. **Cocculina tasmanica**, Pilsbry.

Acmæa parva, Angas, var. *tasmanica*, Pilsbry in "Nautilus," 1895, p. 128. *Nacella tasmanica*, Tate and May, Proc. Roy. Soc. S.A., vol. xxiv, p. 102, 1900; Proc. Linn. Soc. N.S.W., 1901, p. 411, pl. xxvii, figs. 89, 90. *Cocculina meridionalis*, Hedley, Memoirs Austral. Museum, vol. iv, pt. 6, 1903, p. 331, fig. 64 in text.

A single specimen, which was examined by Mr. C. Hedley, who kindly reported on it as follows: "Sculpture worn off, but in size, shape, and general appearance it is just like my *C. meridionalis*." Quite recently he informed us that his species was identical with Pilsbry's *tasmanica*. One of us, who has a syntype of the latter in his collection, compared our shell with it and found it to agree in every respect; the deciduous nucleus is still present, but the epidermis, and with it the sculpture, are lost. The type was dredged by Mr. May in 10 fathoms in Fred. Henry Bay, Tasmania. This is a very interesting addition to our fauna.

55. Genus (?). Plate XXVII, figs. 52–54.

Shell small, flat, oblong-scutiform, sides almost parallel, the posterior end having a broad inward curve; the apex minute, laterally disposed and almost terminal; anterior end imperfect. Sculpture consists of numerous small rounded and irregularly spaced concentric growth-periods, more distant anteriorly, the primary periods scarcely so oblique to the axis as the nucleus. Colour whitish. Protoconch distinctly marked off, smooth, cap-shaped, with a slightly flattened rim-like margin; it consists of about one turn, somewhat oblique to the major axis. The lateral margins slightly laminated and with an upward curve, thus giving the dorsal surface a slightly concave aspect. Interior slightly polished and with shallow incised lines upon the inner slope of the lip, indicating the line of attachment; immediately underneath these lines are right and left small narrow muscular impressions, the left largest and rather more anterior. Length, in broken condition, 7·76 mm.; breadth, 4·66 mm.

Obs. The generic position of this unique specimen is somewhat of a puzzle to us, as we are not acquainted with anything to match it. It may belong to some tectibranchiate genus, perhaps of the family *Pleurobranchidæ*.

56. (?) **Recluzia**, sp. Plate XXVII, figs. 55, 56.

Shell small, turbinate, imperforate, thin and fragile, smooth, with a squarish mouth. Sculpture consists of minute growth-striæ perceptible only here and there; near the outer lip several small, close, and more distinct growth-periods mark the position of successive lip-margins. Colour yellowish-horn, white underneath the epidermis, which is very thin, microscopically delicately roughened, which obliterates almost all trace of gloss. Spire conoidal, with a blunt apex. Protoconch rounded, obtuse, but its character is obscured by foreign growth upon it. Whorls 4, rapidly increasing, slightly convex, the last comparatively large, with a few longitudinal light swellings. Suture impressed, not deep. Aperture oblique, large, squarish. Outer lip sharp, inflexed above and strongly angled at the periphery, reaching the pillar in a slight curve and at a right angle to it. Inner lip forming a narrow rounded callosity over the but-little-excavated columella, which ends in a point at the base and forms a small but distinct notch with the outer lip, which is slightly thickened in the proximity. Altitude, 3·83 mm.; diameter, 3·29 mm.

Obs. One empty specimen of this curious shell was obtained. Mr. Hedley thinks it the greatest puzzle of the whole collection, and he offers two suggestions—(1) that it is a larval shell; (2) that, if adult, it may represent a new genus near *Ianthina.* We are more inclined to consider it as a larval shell. The colour and presence of an epidermis remove it from *Ianthina,* but they would not exclude it from *Recluzia.* However, the distinct angle of the outer lip and the but slightly convex whorls are somewhat inconsistent with that genus, of which the young forms are unknown to us. Unfortunately we do not know the animal. We publish description and figures in the hope that some scientist may give us a clue to the true generic position.

57. Ancilla, sp.

A number of specimens of an apparently new species were obtained, but none of them is perfect, and it is impossible to describe them. The species is very small; length, about 5 mm.

58. Typhis, sp.

A very poor specimen turned up. It may be *T. yatei,* C. and F., but it is much smaller than that species, and in too bad condition for identification. It certainly is not *T. zealandica,* Hutt.

59. Solarium, sp.

A fragment only.

60. Siphonalia, sp.

A number of small dead shells, but they seem too young to deal with.

61. **Cerithiopsis**, sp.

One dead imperfect shell, no doubt a new species, but not good enough to give a figure and description of it.

62. **Scala**, sp.

One dead shell, imperfect, about 6 mm. long, distinctly spirally lyrate and with quite irregular longitudinal folds.

63. **Eulima**, sp.

One small decollated dead specimen. Mr. C. Hedley reports on it, "There are several species like this, and I would not describe it unless a good series were available for study."

Scaphopoda.

64. **Dentalium nanum**, Hutton.

A number of dead shells, some of them perfect, were dredged.

65. **Dentalium (Fissidentalium) zelandicum**, Sowerby.

A few nearly perfect shells and a number of fragments were got—all dead shells.

66. **Dentalium (Fissidentalium) huttoni**, Kirk.

Two small dead shells.

67. **Cadulus**, sp.

One nearly adult and a few very small dead shells, insufficient for description.

Appendix.

The following species, mentioned in our paper, have been dredged by Captain J. Bollons, of the Government steamer "Hinemoa," in 37 fathoms, off Cuvier Island, north by west: *Pleurotoma* (*Hemipleurotoma*) *nodilirata*, M. and S.; *Vulpecula* (*Pusia*) *biconica*, M. and S.; *Omalaxis amœna*, M. and S.; *Aclis semireticulata*, M. and S.; *Minolia plicatula*, M. and S.

EXPLANATION OF PLATES XXI - XXVII.

Plate XXI.

Fig. 1. *Philine constricta*, M. and S. 5 mm. by 3 mm. Suter del.
Fig. 2. „ *umbilicata*, M. and S. 3·5 mm. by 2·25 mm. Suter del.
Fig. 3. *Cylichna simplex*, M. and S. 4·4 mm. by 2·2 mm. Murdoch del.
Fig. 4. „ „ „ View of apex. Murdoch del.
Fig. 5. *Ringicula delecta*, M. and S. 4·4 mm. by 2·9 mm. Murdoch del

Fig. 6. *Actæon craticulatus*, M. and S. 9 mm. by 4·5 mm. Suter del.
Fig. 7. *Daphnella protensa*, Hutt. 8 mm. by 3·2 mm. Murdoch del.
Fig. 8. ,, ,, ,, Protoconch. Murdoch del.
Fig. 9. *Drillia optabilis*, M. and S. 10·7 mm. by 3·9 mm. Murdoch del.

PLATE XXII.

Fig. 10. *Pleurotoma nodilirata*, M. and S. 19·6 mm. by 8·5 mm. Murdoch del.
Fig. 11. *Pleurotoma nodilirata*, M. and S. From the Pliocene. Murdoch del.
Fig. 12. *Pleurotoma alticincta*, M. and S. 15·7 mm. by 5·75 mm. Murdoch del.
Fig. 13. *Pleurotoma alticincta*, M. and S. Protoconch. Murdoch del.
Fig. 14. ,, *augusta*, M. and S. 10·3 mm. by 3·9 mm. Murdoch del.
Fig. 15. *Pleurotoma augusta*, M. and S. Showing sinus. Murdoch del.
Fig. 16. ,, ,, ,, Protoconch in profile. Murdoch del.
Fig. 17. *Pleurotoma augusta*, M. and S. Protoconch from above. Murdoch del.
Fig. 18. *Pleurotoma eremita*, M. and S. 5·8 mm. by 2·4 mm. Murdoch del.
Fig. 19. *Pleurotoma eremita*, M. and S. Protoconch. Murdoch del.

PLATE XXIII.

Fig. 20. *Fulguraria hedleyi*, M. and S. 61 mm. by 18 mm. Suter del.
Fig. 21. ,, ,, ,, Protoconch. Suter del.
Fig. 22. *Vulpecula biconica*, M. and S. 5 mm. by 2·8 mm. Suter del.
Fig. 23. } Fig. 24. } *Marginella fusula*, M. and S. 6·9 mm. by 3·1 mm. Murdoch del.
Fig. 25. } Fig. 26. } *Marginella hebescens*, M. and S. 3·8 mm. by 2·1 mm. Murdoch del.

PLATE XXIV.

Fig. 27. *Cryptospira ficula*, M. and S. 3·5 mm. by 2·2 mm. Murdoch del.
Fig. 28. *Megalatractus maximus*, Tryon. Protoconch. Suter del.
Fig. 29. *Diala subcarinata*, M. and S. 2·9 mm. by 1 mm. Murdoch del.
Fig. 30. } Fig. 31. } Fig. 32. } *Omalaxis amœna*, M. and S. 3 mm. by 1 mm. Murdoch del.
Fig. 33. } Fig. 34. } *Aclis semireticulata*, M. and S. 3·3 mm. by 1·7 mm. Murdoch del.

PLATE XXV.

Fig. 35. *Scala levifoliata*, M. and S. 5·7 mm. by 1·6 mm. Murdoch del.
Fig. 36. ,, ,, ,, Protoconch. Murdoch del.
Fig. 37. *Odostomia marginata*, M. and S. 4·5 mm. by 2·3 mm. Murdoch del.
Fig. 38. *Eulimella levilirata*, M. and S. 6 mm. by 1·4 mm. Suter del.
Fig. 39. *Pyramidella tenuiplicata*, M. and S. 3·2 mm. by 0·8 mm. Murdoch del.
Fig. 40. *Eulima vegrandis*, M. and S. 6·9 mm. by 1·9 mm. Murdoch del.
Fig. 41. ,, ,, ,, Side view of body-whorl. Murdoch del.
Fig. 42. *Eulima infrapatula*, M. and S. 5 mm. by 2 mm. Murdoch del.
Fig. 43. ,, *bulbula*, M. and S. 13 mm. by 3 mm. Suter del.
Fig. 44. ,, ,, ,, Protoconch. Suter del.

PLATE XXVI.

Fig. 45. } *Minolia textilis*, M. and S. 4·3 mm. by 3·8 mm. Murdoch del.
Fig. 46. }
Fig. 47. }
Fig. 48. } ,, *plicatula*, M. and S. 4·5 mm. by 3 mm. Murdoch del.
Fig. 49. }

PLATE XXVII.

Fig. 50. } *Cirsonella granum*, M. and S. 1·75 mm. by 1·75 mm. Murdoch
Fig. 51. } del.
Fig. 52. Genus (?). Dorsal surface. 7·7 mm. by 4·6 mm. Murdoch del.
Fig. 53. ,, Ventral surface. Murdoch del.
Fig. 54. ,, Nucleus, greatly magnified. Murdoch del.
Fig. 55. } (?) *Recluzia* sp. 3·8 mm. by 3·3 mm. Murdoch del.
Fig. 56. }

ART. XXXV.—*Results of Dredging on the Continental Shelf of New Zealand.*

By W. H. WEBSTER, B.A.

[*Read before the Auckland Institute, 6th December, 1905.*]

Plate XXXVIII.

Mangilia murrhea (= fluor-spar), n. sp. Figs. 1, 1*a*.

Shell semitransparent, white. Whorls $4\frac{1}{2}$, including a smooth protoconch of one and a quarter whorls. Sculpture : Longitudinal ribs, stronger on the earlier whorls, weaker towards the last, which has about fifteen ribs extending to the suture ; these ribs are crossed by faint spirals, the posterior or peripheral being the strongest, two on the second whorl, three above the aperture, a fourth on the body-whorl, beyond which the longitudinal ribs only persist a short distance. The whorls are tabulated above the periphery ; a 1 in. objective shows many subsidiary spiral striations between the main spirals. Suture well marked by a narrow overlapping of each whorl by the one following. The base has fifteen spiral striæ. Aperture with a conspicuous sinus in the infrasutural tabulation, but there is no anal fasciole. The type is waterworn. Length, 5 mm. ; breadth, 3 mm.

"Allied to *M. flexicostata*, Suter (H. S.)."

Mangilia infanda (= disreputable), n. sp. Fig. 2.

Shell white, chalky. Whorls 5, rounded, including a smooth protoconch of about one whorl and a half. Sculpture : Longitudinally vertically ribbed, the ribs strong right up to the suture and persisting faintly down the base ; body-whorl with about nine ribs. Strong spirals cross the ribs, two on the second whorl, three above the aperture, a fourth and faint fifth on the body-whorl. The sutures of the early whorls are sharp, of those succeeding concavely rounded. The base is spirally striated. The type is worn—the protoconch damaged, and the outer lip broken away for a quarter of a whorl. There are spiral striations between the main spirals, and these are strongest on the somewhat hollow infrasutural tabulation; there is no anal fasciole. Length, 6 mm.; breadth, 3 mm.

"Near *M. dictyota*, Hutton (H. S.)."

Drillia multiplex, n. sp. Fig. 3.

Shell fusiform, white, chalky. Whorls 5, including a glossy protoconch of one whorl and a quarter; each whorl is tabulated below the suture, and the tabulation ends anteriorly in a prominent spiral thread; then follows a second tabulation, terminating in a row of oval gemmules, about fifteen on the last whorl; just posterior to the gemmules is a fine spiral thread carrying the abruptly curved sharp threads of the anal fasciole; these threads are regularly interspaced, elevated and very distinct on both tabulations; they are covered by the first spiral, but override the second with a sharp downward bend; on the body-whorl they change their character, becoming mere striations, and more numerous than in the fasciole; in this respect they differ rom *Drillia dilecta*, Hedley. A second slightly gemmed thread appears on the body-whorl, and two fine spiral lines on the anterior tabulation. On the base are four strong spirals, and on the canal about ten much weaker. The lip is too much broken away to render reconstruction desirable. Length, 5·5 mm.; breadth, 2·5 mm.

I have just seen a recent shell dredged by Mr. C. Cooper off Poor Knights in 70 fathoms; it is pale-pink.

Daphnella aculeata, n. sp. Figs. 4, 4*a*, 4*b*.

Shell buff-coloured, lighter towards the apex and canal. Whorls 5, including a reticulated protoconch of one whorl and a quarter. Sculpture: Longitudinally and slightly diagonally ribbed, the ribs crossed by two strong spiral keels, ribs and keels about equal in strength, the intersections forming sharp points. The last whorl has upon the base four additional keels, the space between the two peripheral keels and the four on the base being greater than that between any other two; a fine thread is visible in this wide space, there is also a duplication of the posterior keel; the last whorl has about twelve ribs. The sutures of the early whorls are sharp, those of the latter are concavely round. The columella descends vertically from the body-whorl. The canal, which is straight, has about eight faint striations. The space between the suture and the first spiral keel contains the anal fasciole; a 1 in. objective reveals faint radial striations between the keels, also the reticulation of the protoconch. Of two shells before me I figure the smaller because it is almost perfect; both shells have five whorls, but the larger has three keels instead of two, the third being introduced near the suture. The sinus of the type is so little damaged that to draw it perfect can scarcely be called reconstruction. Type: Length, 5 mm.; breadth, 3 mm. Larger specimen: Length, 6 mm.; breadth, 3·3 mm.

Newtoniella stiria (= icicle), n. sp. Figs. 5, 5*a*, 5*b*.

Shell acicular, pale-yellow, vitreous, with twenty flat whorls, of which three represent the juvenile stage. A 1 in. objective reveals one smooth and two sculptured whorls; the earlier of these two is finely radially ribbed, the latter has in addition spiral striations. The sculpture of the rest of the shell consists of three faintly jewelled spirals to each whorl except the last, which has four. The apex diminishes in diameter with the beginning of the definitive sculpture. Sutures scarcely marked; base smooth; columella spiral, white; canal sharply turned to the left. The outer lip is damaged; a side view therefore shows more of the columella than would otherwise be visible. Length, 9 mm.; breadth, 2 mm.

Triphora infelix, n. sp. Figs. 6, 6*a*.

Shell of fifteen slightly rounded whorls with a five-whorled juvenile apex. Whorls 6 to 8, have two jewelled spirals, a third being introduced between the other two on the ninth, at which time also a line denoting a fourth spiral appears in the suture, developing into a plain spiral on the last whorl. Sculpture: Oval jewels almost vertically above one another, united longitudinally and spirally by a raised band. Protoconch keeled near the centre of each whorl and finely radiately ribbed. Sutures distinguished by a slightly deeper groove; base with two obscure spirals. Shell rotten, the aperture broken beyond reconstruction; columella wanting. General outline very slightly convex. Length, 6 mm.; breadth, 1·5 mm.

Rissoia pingue (= plump), n. sp. Figs. 7, 7*a*, 7*b*.

Shell white, of four and a half rounded but slightly flattened whorls, of which a very glossy protoconch occupies the first one and a half. Sculpture: Fine spiral lines, three on the third and four on the body whorl above the aperture; the spirals are crossed by close-set longitudinal ribs as strong as the spirals, they die out on a level with the posterior angle of the aperture, and the base has three spirals only. Columella vertically arcuated; aperture diagonal-oval, a little angled where the outer lip joins the columella, behind which is a deep groove. The outer lip is thickened externally, especially where it joins the body-whorl. Length, 2 mm.; breadth, 1·25 mm.

"Near *R. gradata*, Hutton (H. S.)."

Columbella dæmona, n. sp. Figs. 8, *8a*.

Shell dull, pale-cream colour with rufous markings. Whorls 5, slightly rounded, of which the first is glossy without sculpture while the second is finely radiately striated. Sutures well marked; columella vertical, with a slight covering of enamel; lip thin, with twelve faint denticles. Canal with about fifteen obscure striations, the entire shell with fine incremental striæ. Length, 7 mm.; breadth, 2 mm.

Columbella compta (= neat), n. sp. Figs. 9, *9a*.

Shell white, with four rather glossy whorls, one of which is the shining protoconch. Sculpture: Close spiral cinguli crossed by fine incremental striæ. There are no spirals visible on the earliest sculptured whorl. Sutures well marked; columella vertical; outer lip thin, devoid of denticles. Length, 3 mm.; breadth, 1 mm.

EXPLANATION OF PLATE XXXVIII.

Fig. 1. } *Mangilia murrhea*, Webster.
Fig. *1a.* }
Fig. 2. ,, *infanda*, Webster.
Fig. 3. *Drillia multiplex*, Webster.
Fig. 4. }
Fig. *4a.* } *Daphnella aculeata*, Webster.
Fig. *4b.* }
Fig. 5. }
Fig. *5a.* } *Newtoniella stiria*, Webster.
Fig. *5b.* }
Fig. 6. } *Triphora infelix*, Webster.
Fig. *6a.* }
Fig. 7. }
Fig. *7a.* } *Rissoia pingue*, Webster.
Fig. *7b.* }
Fig. 8. } *Columbella dæmona*, Webster.
Fig. *8a.* }
Fig. 9. } ,, *compta*, Webster.
Fig. *9a.* }

ART. XXXVI.—*Additions to the New Zealand Fauna.*

BY W. H. WEBSTER, B.A.

[*Read before the Auckland Institute, 6th December, 1905.*]

Plate XXXIX.

Trochus camelophorus (= rope-bearing), n. sp. Figs. 1, 1*a*.

Shell solid, conical, rose-coloured with darker markings of the same. Whorls $5\frac{1}{2}$, somewhat bulging at the periphery. Sculpture: Rounded cinguli with rope-like markings, three on the third whorl, then four, five above the aperture, six on the outer lip above the periphery; between the third and fourth ropings on the penultimate whorl a narrow cingulus appears. Protoconch two-whorled, smooth, waterworn. Sutures marked by a deep groove behind the first roping of succeeding whorl. Base with six flat spirals separated by a slightly narrower furrow; on these spirals are two or three subspirals. The colouring only appears on the raised surfaces; it fades towards the false umbilicus, which is funnel-shaped, with two deep spiral grooves, the posterior of which does not reach the columella-edge. The columella is nearly vertical, very slightly arcuated, and has what looks like a prominent tubercle near its insertion (it is really the end of a spiral fold); the ridge separating the two grooves is rounded and highly polished. Aperture subquadrate; lip simple, advancing at the suture. Height, 1 cm.; major diameter, 12 mm.

Hab. Cape Maria van Diemen.

Animal and operculum unknown.

One specimen in my collection has the grooves in the funnel narrower and the dividing ridge wider and slightly concave. The pink colour of this shell may be due partly to exposure.

Mr. C. Hedley very kindly compared the type with the *Trochi* in the Australian Museum, and writes, "I should regard this shell as a very distinct new species."

Trochus (Clanculus) takapunaensis, n. sp. Figs. 2, 2*a*.

Shell with five slightly rounded whorls, of which one and a half are smooth. Sculpture: Smooth rounded spirals, of which the two upper are close together and the others far enough apart to admit a fine spiral thread in the radially striated hollow between them; above the peripheral spiral on the body-whorl is a narrower one which appeared in the suture of the third whorl. Colour yellow-grey, with very dark irregular patches all of which shade into white from left to right. Sutures deeply grooved behind the succeeding whorl. Base with seven or eight spirals separated by furrows of the same width, coloration as above. False umbilicus deep, funnel-shaped, contracted at the margin by a spiral rib with occasional tubercles; columella arcuated, having a blunt tubercle on the funnel side, and a long fold transversely wound over the anterior end and passing into the shell. In my figure 2*a* the white extension near the body-whorl represents the spread of the columella at the point of junction. Aperture with numerous irregular denticles, some of them extending far into the shell. Height, 5 mm.; major diameter, 7·5 mm.

Hab. Takapuna, in shell sand.

Mr. C. Hedley, to whom I sent this shell as *T. ringens*, is good enough to reply, ". . . too remote from that species to be worth comparing . . . Your shell has a close resemblance to the Victorian *C. plebeius*." I believe that the transverse fold on the columella, and the absence of a biplicate tooth at that point, separates this shell from *C. plebeius*, and also from *C. variegatus*, Ad., recorded by the late Professor Hutton (see Man. N.Z. Mollusca, 1880, p. 95).

Trophon waipipicola, n. sp. Figs. 3, 3*a*, 3*b*.

Shell fusiform, grey, with seven whorls, of which one and a half form the protoconch, which is smooth, with a smooth keel on the last half-whorl. Sculpture: A noduled keel on the second and third whorls, a second row appearing on the fourth and fifth in the suture; the body-whorl has three keels, the middle one being the smallest; the nodules are lengthened in a spiral direction, and are situated on longitudinal buttresses which are faint towards the suture and the base. There are no spiral striæ between the keels, such as one finds in *Siphonalia dilatata*, of which the shell is otherwise a miniature; the tabulation below the suture is plain; on the base are four spirals, the lowest being the strongest. The canal is straight and open, the extremity projecting beyond the pillar, on which are a few transverse folds. Columella smooth, brown, arcuated and slightly concave. The horny operculum has the nucleus apical, and a projection on the inner side as in *Siphonalia;* the attachment scar is auriform. Dentition: Five cusps on straight plates narrowed anteriorly, the centre and two outside cusps being the largest; there is a reversely arched strengthening-ridge on each plate, and a similar small one above it; the laterals are bicuspid, webbed up to the points. There are three slight folds on the outer edge of the canal. Height, 1 cm.; major diameter, 5 mm.

Hab. Waipipi, on mud-flat.

The operculum and sculpture of shell are similar to *Siphonalia;* the dentition is nearer *Trophon.*

Phrixgnathus serratocostata, n. sp. Figs. 4, 4*a*.

Shell of four and a half rounded whorls, horny without markings; the limitation of the coarse protoconch is not clearly defined, but there is a one-and-a-half-whorled smooth apex; the body-whorl has twenty-one flanges, wide on the periphery and rapidly diminishing towards the suture, the entire length beset with close-set hooked teeth, turned towards the apex: the spaces between are clearly reticulated with revolving and incremental striæ; the flanges are not continued on the base, but are represented by striæ of varying strength. Periphery bluntly angled; columella widely reflexed above, perforation about one-twelfth of the major diameter. Major diameter, 1 mm.; height, 0·75 mm.

Hab. Waiuku.

Two specimens, one with the animal; but as my microscope does not easily separate very minute teeth I have deferred mounting the radula, and depended only upon shell characteristics.

Unio (Diplodon) websteri, Simpson. Figs. 5, 5*a*, 5*b*.

As this shell has not yet been figured, I give a careful pen-and-ink drawing, after accurate measurements both of outline and sculpture. I also at fig. 6 give a similar drawing of *Diplodon novæ-hollandiæ*, Gray, for comparison.

Mr. H. Suter* says, "I consider *Diplodon websteri* as a *D. menziesi* in which the nodulous sculpture is developed to the highest degree." If this is correct we should find every stage of nodulous development; such is, however, not the case as far as I am aware. There is, I believe, nothing between the mere indications of such sculpture in *D. menziesi* and the fully developed *D. websteri.* I have recently seen a single valve of this shell in Mr. R. Murdoch's collection: it was found in the Wanganui River. The hinge of Simpson's species (which must not be confounded with *Unio websteri*, Wright) is much more developed than that of *D. menziesi.* The shell I have figured is the co-type, the type being in the Smithsonian Institute at Washington. I have other specimens in which the nodules are carried out to the anterior margin, and the outline approximates more to that of the Australian shell, inasmuch as the

* Trans. N.Z. Inst., vol. xxxvii, p. 236.

anterior and posterior dorsal angles are much less apparent, thus narrowing the shell before and behind. Old specimens are much more thickened within than *D. menziesi*, and consequently much heavier ;] the nacre is also more brilliant.

I append the short description of this shell by Mr. Simpson ("Nautilus," July, 1902) : "Shell long, rhomboid, compressed or subcompressed, inequilateral ; beaks subcompressed, pointed, their sculpture apparently a few irregular lachrymose nodules arranged in a somewhat radial pattern ; surface with uneven growth-lines and impressed rest-marks, sculptured throughout with lachrymose nodules, which are often V-shaped, those along the upper part of the low posterior ridge slightly knobbed ; epidermis dark olive-green clouded with lighter green, rather dull ; pseudo-cardinals small, subcompressed, granulose, two in each valve ; laterals straight, two in the left valve, one in the right ; muscle-scars small, shallow, and irregular ; nacre bluish, lurid-purple near and in the beak-cavities, thicker in front. Length, 67 mm. ; height, 32 mm ; diameter, 14 mm. : length, 62 mm. ; height, 32 mm. ; diameter, 17 mm. . . . A new species apparently allied to *D. novæ-hollandiæ*, Gray, of Australia, but smaller, less inflated, and less solid than that species. In *D. novæ-hollandiæ* the anterior one-third of the shell is almost destitute of nodules, in the present species the whole surface is covered with them. These resemble somewhat those found in the *Unio tuberculatus*, Barnes, but are less elevated."

Turbo shandi, Hutt. (Astralium Ind. F.N.Z.)

I recently received from Mr. R. Murdoch two specimens of this shell authenticated by the late Professor Hutton : they proved to be the young of *Turbo granosus*, Mart.

EXPLANATION OF PLATE XXXIX.

Fig. 1., Fig. 1*a*. — *Trochus camelophorus*, Webster.
Fig. 2., Fig. 2*a*. — *T.* (*clanculus*) *takapunaensis*, Webster.
Fig. 3., Fig. 3*a*., Fig. 3*b*. — *Trophon waipipicola*, Webster.
Fig. 4., Fig. 4*a*. — *Phrixgnathus serratocostata*, Webster.
Fig. 5., Fig. 5*a*., Fig. 5*b*. — *Unio* (*Diplodon*) *websteri*, Simpson.
Fig. 6 *Unio* (*Diplodon*) *novæ-hollandiæ*, Gray.

ART. XXXVII.—*On the Anatomy of* Paryphanta atramentaria, *Shuttleworth.*

By R. MURDOCH.

[*Read before the Wellington Philosophical Society, 7th December,* 1905.]

Plate XX.

AN example of this handsome species was handed to the writer by Mr. Charles Hedley of the Australian Museum, and for which best thanks are here tendered.

In shell characters this well-known Victorian species is typical of *Paryphanta* ; the shell consists very largely of conchin —in fact, with the exception of the apical whorls, consists almost wholly of that substance. This is a feature quite in accord with certain of the New Zealand and Tasmanian species. The type of the genus, *P. busbyi*, Gray, is more largely built up of calcareous matter than any other member of the group that comes within my knowledge ; nevertheless, it is enveloped in an exceedingly heavy coating of conchin. Suter* has drawn attention to the predominance of this substance in the shells of *Paryphanta*, and it appears to be the one prominent feature characteristic of the genus, and by which it may be distinguished from the nearly akin *Rhytida*.

The animal (preserved in alcohol) is a deep-blue, with a narrow area of yellowish-white around the margin of the foot. The rugæ large, irregular, and not forming continuous rows. On the dorsal surface of the neck are two prominent lines or grooves which proceed from the head back under the mantle. Upon the tail there appears to be no median groove, the rugæ is a trifle smaller and less pronounced than on the neck and sides. The footsole whitish, and contracted into numerous deep folds — in life it is doubtless much expanded. The mantle-margin yellowish-white, a somewhat prominent lappet at the respiratory and anal pores, also a smaller one towards the left side. The head of the animal is much drawn in, and the labial projections are not discernible ; the tentacles are also completely retracted.

Internal Anatomy.—The buccal mass (figs. 1, 2) has the usual form in this group of animals ; it is large and muscular, with the posterior end curved down and forward. The retractor muscle is a large, powerful structure ; it has no attachment with the posterior end of the buccal mass, or, to be more correct, what appears to be the posterior end (fig. 2), but is applied to

* "Journal of Malacology," 1899, vol. vii, pt. 3, pp. 49, 50.

all sides except a narrow dorsal area. The greater portion of the retractor goes to the ventral side, where it forms a well-defined dense mass (fig. 1*a*). Proceeding anteriorly from this mass are strong widely spreading muscular bands, which envelop the ventral and lateral areas of the buccal mass. The posterio-lateral attachments of the retractor muscle are continuous with the ventral attachment, and sweep up on to the dorsal surface, when, proceeding forward, they coalesce and form a thin envelope. On either side immediately above the ventral muscular mass is a small area in which the constrictor muscle is not enveloped by the external muscular sheath (fig. 1*b*), on each area is a well-marked flexure, which on dissection proves to be the junction between the curved down and forward posterior portion of the buccal mass and that immediately above; the two parts are woven together; the odontophoral cartilage and accompanying muscles curve down and terminate in this area, which must be regarded as the true posterior termination of the buccal mass. The form of attachment of the retractor muscle proves to be somewhat variable in the different species. *P. fumosa*, Ten.-Woods,* a Tasmanian species, presents a markedly different condition from what obtains in *P. busbyi* and *P. hochstetteri;* while the species under notice, though nearer to the condition of the New Zealand species, forms a connecting-link with *P. fumosa.*

The radula is about 23 mm. in length by 5 mm. in width, and is armed with 105 transverse angular rows of teeth. The number of teeth per row is somewhat variable; towards the posterior end of the radula, where they form an acute angle, we get the formula 66–0–66, while on the middle portion 63–0–63 appears to be the more usual number. Suter refers to this species in his description of *P. edwardi*,† and gives the formula 50–1–50. The absence or presence of a rachidian tooth in this genus is not a matter of much importance; in the radula before me it is certainly non-existent. The tooth on either side of the central cleft (fig. 3) is minute and probably functionless; the succeeding teeth large, all aculeate, gradually increasing in size; thence uniform for a considerable number, when they again gradually become shorter; finally, towards the margin (fig. 4), short and robust.

The œsophagus (*œs.*) enters the buccal cavity in the anterior third; a salivary duct (*s.a.*) on either side of the œsophagus empty into the cavity. The salivary glands (*s.g.*) are small and almost completely fused together. The stomach and tract

* Trans. N.Z. Inst., vol. xxxvi, pp. 156–61, pl. vi, 1903, issued 1904.
† Proc. Mal. Soc. Lond., vol. iii, p. 290.

of the intestine are similar to other members, and call for no special mention.

The nervous system, with regard to the position of the several ganglia and their connectives, is identical with other species of the genus. The same may be said of the muscular system, in so far as the form and position of the principal muscles, with the exception of the form of attachment of the buccal-mass retractor, which has already been dealt with. The right-tentacle retractor passes between the branches of the genital system.

The pedal gland forms a long, narrow, much-folded tube, resting upon the floor of the body-cavity, its posterior end imbedded in the muscles of the foot, to which it has a muscular attachment.

Generative Organs (fig. 5).—The penis forms an elongated, club-shaped organ, with the retractor muscle inserted at the apex. The vas deferens arises near to the distal end of the penis; proceeding forward it is for some distance attached to the wall of the male organ, adding to the club-shaped appearance of the latter; thence free, and reduced to a very slender tube until it rests upon the anterior portion of the oviduct. From this point it becomes somewhat more prominent, and finally forms a sac-like enlargement as it enters the posterior termination of the free tube of the oviduct. The interior walls of the posterior portion of the penis, and the attached portion of the vas deferens, are clothed with minute papillæ-like structures. The receptaculum seminis arises from the free oviduct where the latter becomes merged in the sacculations of the uterus. It arises as a small sac, which in the natural position of the organs is enveloped by a large fold of the uterus, thence reduced to a slender tube, and terminating in an oval-shaped enlargement tucked in at the base of the albumen-gland. The albumen-gland is a large, irregularly ovate mass; from it proceeds the hermaphrodite duct, which is somewhat convoluted. The hermaphrodite gland consists of three or more follicular masses imbedded in the right lobe of the liver. These structures are difficult to follow, as in colour they are similar to the surrounding mass.

Pallial Organs (fig. 6).—The kidney is shortly tongue-shaped, narrowed anteriorly, and curved to the left, with the pericardium resting against the left concave margin. In length it is about one-third greater than the pericardium, and less than half the length of the lung. The ureter follows the margin of the kidney and opens into the right posterior corner of the lung, close to the rectum. The venation of the lung is beautifully clear and distinct, due to its pigmented condition. In the figure given no attempt has been made to delineate the finer details, which includes the delicate network of connectives between the efferent and afferent branches. On the rectal side of the lung are numerous efferent and afferent vessels, uniform in size and finely branched; while on the cardiac side, in addition to some small, short tributaries, are four strongly marked and much-branched veins. The posterior of these veins, which unites with the great pulmonary vein a little anterior to the junction of the latter with the auricle, is much the largest; it divides into two prominent branches, each with numerous lesser tributaries. The afferent vessels in this area are correspondingly large and much branched.

EXPLANATION OF PLATE XX.

Fig. 1. }
Fig. 2. } Buccal mass, &c.
Fig. 3. }
Fig. 4. } Teeth.
Fig. 5. Generative organs.
Fig. 6. Pallial organs.

LETTERING.

alb.g. Albumen-gland.
af.v. Afferent pulmonary vessels.
ef.v. Efferent pulmonary veins.
h.g. Hermaphrodite gland.
h.d. Hermaphrodite duct.
k. Kidney.
l.l. Left mantle lobe.
œs. Œsophagus.
p. Penis.
p.v. Great pulmonary vein.
per. Pericardium.
r. Rectum.
r.m. Retractor muscle.
r.s. Receptaculum seminis.
r.l. Right mantle lobe.
s.d. Salivary ducts.
s.g. Salivary gland.
u. Ureter.
vd. Vas deferens.

ART. XXXVIII.—*Notes on New Zealand* Mollusca, *with Descriptions of New Species and Subspecies.*

By HENRY SUTER.

Communicated by A. Hamilton.

[*Read before the Wellington Philosophical Society, 4th October,* 1905.]

Plate XVIII.

Meleagrina radiata, Lamarck (1836).

Lamarck, Anim. s. vert., 2nd ed., vol. vii, 1836, p. 107.

Specimens of this shell were found at the Kermadec Islands by Captain J. Bollons, and I am indebted to Professor W. H. Dall, of Washington, for their identification.

Pecten imparvicostatus, Bavay (1905).

Pecten australis, Hutton, Journ. de Conch., vol. xxvi, 1878, p. 54; Man. N.Z. Moll., 1880, p. 171 (not of Sowerby). *Pecten asperrimus*, Hutton, Proc. Linn. Soc. N.S.W., vol. ix., 1884, p. 531 (not of Lamarck); Suter, Trans. N.Z. Inst., vol. xxxiv, 1902, p. 223; Index Faunæ N.Z., 1904, p. 93 (not of Lamarck). *Pecten imparvicostatus*, A. Bavay, Journ. de Conch., vol. liii, 1905, p. 23, pl. ii, figs. 6, 7.

Hab. Novæ-Zelandiæ mare. Collected by Dr. Gall, of H.M.S. "Archeron" (Bavay): Cape Maria van Diemen; Hauraki Gulf; Nelson; Foveaux Strait; Chatham Islands.

Type in the British Museum.

This species is the *Pecten asperrimus* of New Zealand conchologists. According to Bavay it stands nearest to *P. aktinos* (= *bednalli*, Tate), and also shows some affinity with *P. bifrons*, Lamk. (= *tasmanicus*, Ad. and Ang.) and *P. lividus*, Lamk. (= *tegula*, Wood).

P. gemmulatus, Reeve, is in my opinion an intermediate form between *P. zelandiæ*, Gray, and *P. imparvicostatus*, Bavay. The upper valve shows more or less characters of *P. asperrimus*, Lamk., but the lower valve is very different, and it never attains the size of the latter.

Mytilus canaliculus, Martyn (1784).

Mytilus canaliculus, Martyn, Univ. Conch., vol. ii, 1784, fig. 78. *Mytilus latus* (*novæ-zeelandiæ*), Chemnitz, Conch. Cab., vol. viii, 1785, p. 167, pl. lxxxiv, fig. 747.

As Chemnitz is not binomial in vol. viii, we have to use Martyn's name, which, moreover, has priority. Although his figure is said to be not very good, yet he states that the specimen came from New Zealand, and it is undoubtedly, as I am also assured by Mr. Hedley, the same species as Chemnitz's *M. latus*.

Cardita calyculata, Linné (1767).

Chama calyculata, Linné, Syst. Nat., 1767, p. 1138 (= *Cardita aviculina*, Lamarck, 1819; *C. excavata*, Deshayes, 1852; *C. tasmanica*, T.-Woods, 1876).

For full synonymy of the species see Pritchard and Gatliff, Proc. Roy. Soc. Victoria, vol. xvii (n. s.), 1904, p. 234.

Venericardia corbis, Philippi (1836).

Cardita corbis, Philippi, Enum. Moll. Siciliæ, vol. i, 1836, p. 55 (= *unidentata*, Basterot).

A Pliocene fossil of south Italy, found living in the Adriatic, Mediterranean, and off the Canaries, in deep water (552 fathoms, "Challenger" Exped.).

Specimens of this shell, kindly named by Professor W. H. Dall, were dredged off Little Barrier Island in about 20 fathoms by Mr. R. H. Shakespear. This forms a very interesting addition to the fauna of New Zealand.

Dosinia cœrulea, Reeve (1850)

Artemis cœrulea, Reeve, Conch. Icon., vol. vi, 1850, fig. 25. *Dosinia cœrulea*, Pritchard and Gatliff, Proc. Roy. Soc. Victoria, vol. xvi (n. s.), 1903, p. 133.

The first valve I ever saw of this shell was obtained near Nelson. Later on a number of specimens, but all empty shells, were collected by Mr. A. Hamilton, Director of the Colonial Museum, and he very kindly gave me a few examples. These were kindly named by Professor W. H. Dall. I reproduce here the diagnosis given by Reeve :—

" The blue-tinged *Artemis* : Shell orbicular, convexly tumid in the middle, posteriorly slightly angled, thick, concentrically finely elevately striated, area of the ligament rather broadly excavated, lunule cordate, whitish, tinged with pink and blue towards the umbones.

" *Hab.* Raine's Island, Torres Strait (Captain Ince).

" A solid species in which the concentric striæ are not more prominent at the sides than elsewhere, whilst the delicate pink and blue colouring about the umbones is characteristic."

The specimens I have seen had lost the pink and blue colouring, being so-called " dead shells." The species also occurs at Port Phillip and Western Port, Victoria, but it seems to be a rather rare shell.

Tapes fabagella, Deshayes (1853).

For full reference see Pritchard and Gatliff, Proc. Roy. Soc. Victoria, vol. xvi (n. s.), 1903, p. 134.

This species has turned up in a gathering from Island Bay, Cook Strait, and has to be added again to the list of New Zealand *Mollusca* (Hedley, Records Austral. Museum, vol. v, 1904, p. 89).

Tellina angulata, Hutton (1885).

Hutton, Trans. N.Z. Inst., vol. xvii, 1885, p. 322 ; Pliocene Mollusca of N.Z., in Macleay Mem. Vol., 1903, p. 80, pl. ix., figs. 86, *a*, *b*.

Several valves of this shell were collected near Stewart Island, and two kindly given to me by Mr. A. Hamilton a good many years back. They are light-brown-coloured, but otherwise there is no difference between these recent valves and those from the Pliocene of Wanganui. There is a slight error to correct in Captain Hutton's diagnosis—viz., the *posterior* cardinal of the right valve, and the *anterior* cardinal of the left valve, are *bifid*, as will be seen from the figure of the left valve (fig. 86*b*).

Mactra ordinaria, E. A. Smith (1898).

Mactra triangulare, Hector, Cat. Col. Museum N.Z., 1870, p. 173 (not of Lamarck). *M. elegans*, Hutton, Cat. Tert. Moll. N.Z., 1873, p. 19 (not of Sowerby, 1825).

In the "Pliocene *Mollusca* of New Zealand" Captain Hutton puts his *M. elegans* as a young form of *M. æquilateralis*, Desh. I compared specimens from the Pliocene of Wanganui with my co-types of Smith's species, and found them to agree in every detail.

Mactra lavata, Hutton (1885).

Index Faunæ N.Z., p. 90.

I have examined a specimen obtained by Mr. A. Hamilton at Petane, and gone over the description and figures in the "Pliocene *Mollusca* of New Zealand," and arrived at the conclusion that it is not a *Mactra*, but merely a young form of *Standella ovata*, Gray, of which it therefore should be considered a synonym.

Mesodesma australis, Gmelin (1792).

Mya novæ-zeelandiæ, Chemnitz, Conch. Cat., vol. vi, 1782, p. 30, pl. iii, figs. 19, 20. *Mya australis*, Gmelin, Syst. Nat., xiii, 1792, p. 3221.

Chemnitz being polynomial in vol. vi, the name used by Gmelin has to be adopted.

Corbula macilenta, Hutton (1873)

Corbula macilenta, Hutton, Cat. Tert. Moll. N.Z., 1873, p. 18. (?) *Corbula erythrodon*, Von Martens, Crit. List. Moll. N.Z., 1873, p. 41; Hutton, Journ. de Conch., vol. xxvi, 1878, p. 44; Man. N.Z. Moll., 1880, p. 135; Proc. Linn. Soc. N.S.W., vol. ix, 1884, p. 513; Pliocene Moll. N.Z., 1893, p. 74; Suter, Fauna Novæ-Zealand., 1904, p. 88 (not of Lamarck). *Corbula pura*, Webster, Trans. N.Z. Inst., vol. xxxvii, 1905, p. 279, pl. x, figs. 12, 12*a*.

The late Professor Von Martens was very doubtful about identifying our species with the Japanese *C. erythrodon*, Lamk. Mr. Hedley, in his paper on the *Pelecypoda* dredged in 110 fathoms off Great Barrier Island (this volume), points out that the New Zealand species hitherto known as *C. erythrodon* is very different from Lamarck's species, and that it should be struck off the New Zealand list. Having now read Lamarck's diagnosis I fully agree with Mr. Hedley, and as Hutton's name *macilenta* is available it has to take the place of *erythrodon*. Webster's *C. pura* I do not consider as a distinct species; the radiate striation is more or less distinct in all specimens of *C. macilenta* that came under my observation, and its greater predominance, together with more regular concentric striation, can hardly be considered as sufficient reason why it should be regarded as a species different from *macilenta*. Unfortunately, the Rev. Mr. Webster took the anterior for the posterior margin, and the right for the left valve in consequence.

Chiton huttoni, n. sp. Plate XVIII, figs. 1–6.

General Appearance.—Shell oblong-ovate, angularly raised, valves striated throughout, jugum smooth, girdle with rounded scales; colour yellowish-olive, dull to dark green or brick-red; interior whitish.

The flatly convex anterior valve has seventeen to twenty-four subequal riblets reaching to the apex, and broken up by concentric rugæ of growth; sometimes a few riblets are interspersed which do not extend to the apex; the latter is smooth, and mostly a little excavated posteriorly.

The intermediate valves have the jugum smooth, projecting a little behind; the pleural tracts have about twenty to twenty-five furrows on each side, which near the central area are narrow and not deep, but usually widening and deepening on approaching the margin. Sometimes they are in breadth equal to the riblets, but in some specimens they are narrower. They extend the whole length of the pleural areas. The lateral areas are strongly ribbed, the ribs broken up by the continuance of the grooves on the pleural tracts. Their number is very variable—the usual number is three to four, but sometimes as many as five are found—and some of them may be divaricating, which, however, is not the rule.

The posterior valve has the mucro very little behind the middle; the central area is flatly convex, with the same furrows as the pleural tracts of the intermediate valves; the posterior slope is concave, and the posterior area has eighteen to twenty strongly granose riblets reaching up to the apex.

The girdle bears roundish medium-sized and compactly imbricating polished scales, which under a powerful lens show faint striation.

The colour is very variable; the most common is yellowish-olive, then dull-green is met with, and one of these specimens has the end valves blackish-green; one specimen is brownish-black, and one brick-red. The girdle has the same colour as the valves; sometimes dark bands of variable width and irregular in distribution may be seen.

The interior is mostly bluish-white, pinkish-white in the red specimen. The sinus is deep and narrow, pectinate. The slits on a specimen I disarticulated are: head-valve 9, intermediate valves 1–1, posterior valve 15. All teeth are blunt and pectinate; those of the tail-valve are very unequal in breadth. The valve-callus is rather prominent.

Divergence, 115°. Length, 34 mm.; breadth, 20 mm.

Hab.—Near Dunedin; collected by Mr. A. Hamilton, now Director of the Colonial Museum, who kindly gave me a few specimens many years back.

Type in my collection.

Remarks.—It is at the special request of Miss M. K. Mestayer, of Wellington, that this mollusc is named in honour of Captain Hutton, F.R.S., &c., in acknowledgment of his continuous very kind help she had the honour to enjoy in her conchological studies. Miss Mestayer found a number of years back a *Chiton* at Lyall Bay, which Captain Hutton and myself then thought to be a new species, and lately Miss Mestayer kindly lent me the specimen for description, under condition that it should bear Captain Hutton's name, to which I, of course, with greatest pleasure agreed. However, on closely examining the specimen I found it to be a red-coloured mutatio of *Chiton æreus*, Reeve, one of our rare species. I am very glad indeed to have, nevertheless, an opportunity to comply with Miss Mestayer's wish and unite the name of our honoured leader in natural history with the species.

I once sent a specimen to Mr. E. R. Sykes in London, asking him to be good enough and compare it with the type of Reeve's *æreus* in the British Museum. He, with his usual kindness, however, informed me that it was not the supposed species, but seemed to agree with a specimen in the British Museum from New Caledonia which bears the manuscript name *perpunctatus*, Cpr. I do not doubt for a moment the well-known great ability of Mr. Sykes, but, considering that the affinities of the marine *Mollusca* of New Caledonia and New Zealand are very slender, and having no material from the former country for comparison, I thought it advisable not to take up that manuscript name There may be differences between the two species which a short examination would not reveal.

Chiton huttoni is in its sculpture nearest allied to *C. canaliculatus*, Q. and G., *C. æreus*, Reeve, *C. limans*, Sykes, and *C. stangeri*, Reeve; but the diagnosis and figures now given will easily help to separate it from the other species. I have not seen it yet from any other locality.

Helcioniscus mestayeræ, n. sp. Plate XVIII, figs. 7–9.

Shell solid, oval, slightly narrower in front, depressed-conical; apex at about the front fourth, sharply pointed. Surface sculptured with numerous (about fifty) broad depressed radiating ribs which are crossed by fine concentric striæ. Colour dark-olive with rather distant indistinct bluish-grey radiating bands.

Interior bluish-grey, with a silvery lustre. There are at irregular intervals about eleven broad radiating areas with chestnut-coloured spots and patches, sometimes arranged in a divaricating pattern; between these areas are several radiating bands of an alternately darker and lighter grey colour. These characters are very distinctly visible when the shell is held up against the light, and give it a very beautiful appearance. The central callus is well defined; its colour is reddish-orange, lighter near the margin, finely and minutely dotted with yellow. The muscle-scar is about 3 mm. broad, but slightly impressed.

Length, 49 mm.; breadth, 39 mm.; altitude, 14 mm.

Hab.—Stewart Island.

Type in Miss Marjorie K. Mestayer's cabinet.

I have great pleasure in naming this beautiful species in honour of our most enthusiastic conchologist, Miss M. K. Mestayer.

The animal is unknown. It is quite distinct from any New Zealand species of *Helcioniscus* I have seen, but the general characters approach those of *H. radians*, Gm., more than of any other species.

Haliotis australis, Gmelin (1792).

Haliotis rugoso-plicata, Chemnitz, Conch. Cab., vol. x, 1788, p. 311, fig. 1604. *Haliotis australis*, Gmelin, Syst. Nat., xiii, 1792, p. 3689.

The above-quoted volume of Chemnitz being polynomial, the name given to the species by Gmelin should be used.

Haliotis virginea, Gmelin (1792).

For the same reason, Gmelin instead of Chemnitz should be recognised as author of the species. For both data I am indebted to Mr. Hedley.

Fissurella huttoni, nom. mut.

Fissurella squamosa, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 42.

The specific name *squamosa* being preoccupied by Deshayes, I propose to name the only New Zealand species of the genus in honour of Captain F. W. Hutton, F.R.S., &c. The type is in the Colonial Museum.

Turbo shandi, Hutton (1873).

I had an opportunity of examining Captain Hutton's type specimens in the Colonial Museum, and I found them to be undoubted young specimens of *Turbo granosus*, Martyn.

Turbo helicinus, Born., subsp. tricostata, Hutton.

Turbo smaragdus, Martyn, var. *tricostatus*, Hutton, Proc. Linn. Soc. N.S.W., vol. ix, 1884, p. 355. *Turbo* (*Lunella*) *radina*, Webster, Trans. N.Z. Inst., vol. xxxvii, 1905, p. 277, pl. ix, figs. 1–1*b*.

The nealogic stage of this subspecies had hitherto escaped the notice of conchologists, but this beautifully sculptured shell has now been described and figured by the Rev. Mr. Webster under the name of *T. radina*. It is to be regretted that Webster bestowed a new specific name on this little shell, as further investigation with ample material at hand would have shown him that the form is not adult and not new at all. The larger shells of *T. helicinus* and its subspecies have, as a rule, the first four or five whorls so much eroded that nothing whatever of the neanic sculpture can be discovered; but I have specimens in my collection which show quite unmistakably the peculiar sculpture of the young shell, especially the spiniform projections on the suture. I collected a few specimens of *T. radina* at Takapuna having a diameter from 2·5–5 mm., and these I used for comparison with larger shells. In specimens with about four whorls there is still a perforation left, but with further growth the umbilicus is perfectly sealed up. On examples from the Hauraki Gulf the ribs very soon disappear, the whorls becoming quite smooth, but on shells collected in Lyttelton Harbour the ribs persist on specimens of about 25–30 mm. diameter. I am of opinion that further investigation will show that all young shells of *T. helicinus* are tricostate. The subgenus *Lunella*, Bolten, 1798, used by Webster should be replaced by *Marmorostoma*, Swainson, 1840, as most conchologists reject the names proposed by Bolten.

Trochus (s. str.) conus, Gmelin (1792)

Syn. *T. acutangulus*, Chemnitz (not binomial); *T. elatus*, Lamarck.

A very young specimen of this to me unknown shell was found a few years ago by the lighthouse-keeper of Cape Maria van Diemen, and kindly presented to me. As usual in such cases, there was no literature and no comprehensive collection at my disposal, and I again availed myself of Professor W. H. Dall's great kindness for identifying the specimen. The species is said to occur at the Philippine Islands, and its turning up on the northern shore of New Zealand is rather surprising.

Nerita melanotragus, E. A. Smith (1884).

There has been much confusion about the names bestowed upon the common black Nerite of Australasia. Some years ago I asked Professor Von Martens about his opinion on the subject, and he told me that Gray was the first to use the Latin name *nigra* for our shell, and as he indicated its native country there would be no doubt about the species, and *N. nigra*, Gray, should be used. I accepted Von Martens's opinion, but last year, when I had the pleasure of Mr. Hedley's visit, we discussed the subject, and he strongly advocated the no-doubt-correct view that the same name should be used for the New Zealand shell as for that of Australia and Tasmania. To finally settle the point I wrote to Professor W. H. Dall, asking him which name he would recommend to be used. With the usual great courtesy the following reply was sent to me: "I think I should use *melanotragus*. The species of Quoy and Gaimard, *Nérite noirâtre*, which Gray (in Dieffenbach) latinized as *Nerita nigra*, and identified with the New Zealand shell, according to Von Martens, was of unknown locality, and might not really be the same as Dieffenbach's shell. There is some little doubt about the identity as well as the sufficiency of the diagnosis, and I think I should prefer the name about which no doubt exists. Then there is an earlier *Nerita nigra* (Dillwyn, 1817, following Chemnitz, vol. v, p. 2015), perhaps a variety of *N. bifasciata*, Gm., which would seem to preoccupy the name." This opinion is perfectly in harmony with that expressed by Hedley (Proc. Linn. Soc. N.S.W., 1900, pp. 500–2). For the synonymy of the species see Pritchard and Gatliff, Proc. Roy. Soc. Victoria, vol. xiv (n. s.), 1902, p. 95.

Eulima treadwelli, Hutton (1893).

Eulima micans, Hutton, Trans. N.Z. Inst., vol. xvii, 1885, p. 318 (not of T.-Woods). *Eulima treadwelli*, Hutton, Pliocene Moll. N.Z., in Macleay Mem. Vol., 1893, p. 55, pl. vii, fig. 42.

Recent specimens were collected near Stewart Island, and some kindly given to me by Mr. A. Hamilton. The smaller specimens have six whorls and a length of 4 mm., as mentioned in Hutton's diagnosis, but two are considerably larger, one having seven, the other eight, whorls, the latter measuring 2 mm. by 6 mm.

Ianthina ianthina, Linné (1758).

Mr. Hedley kindly informed me that Linné bestowed the above name on the species commonly known as *I. fragilis*, Lamarck, 1801, and, having priority, should be used instead.

Astralium sulcatum, Martyn, subsp. davisii, Stowe.

Imperator davisii, Stowe, Trans. N.Z. Inst., vol. iv, 1872, p. 218. *Risella kielmannsegi*, Zelebor, Verhandl. Zool. Bot. Gesellsch. Wien, vol. xvi, 1866, p. 913; Reise der "Novara," Moll., pl. i, fig. 11; Hutton, Cat. Mar. Moll. N.Z., 1873, p. 28; Martens, Crit. List Moll. N.Z., 1873, p. 28. *Risella aurata*, Hutton, Journ. de Conch., vol. xxvi, 1878, p. 27. *Risella melanostoma*, Hutton, Man. N.Z. Moll., 1880, p. 79; Suter, Trans. N.Z. Inst., vol. xxxiv, 1902, p. 215; Index Faunæ N.Z., 1904, p. 79. *Astralium pyramidale*, Webster, Trans. N.Z. Inst., vol. xxxvii, 1905, p. 276, pl. ix, figs. 2, 2*a*.

The prevailing tendency amongst conchologists to collect only, as far as possible, adult specimens has led to the neglect of the study of earlier stages of many of our shells. There is no doubt that some of these young forms show characters which in the adult are often more or less obliterated by corrugation, &c. Two instances are already mentioned in this paper—viz., *Turbo shandi* and *Turbo radina*. The specimen described by Zelebor was no doubt obtained in Auckland Harbour; examples were also collected by Mr. T. F. Cheeseman, Rev. Mr. Webster, and myself at Takapuna, but apparently all dead shells. As far as I know the genus *Risella* is littoral, and it puzzled me for a considerable time why our species should not be found alive at Takapuna. The shells I found appeared to be young forms only. Through the kindness of Mr. W. L. May I got a number of Tasmanian young specimens of *Risella melanostoma*, and on comparing these with our supposed *Risella* of the same size I found the two decidedly distinct; also, the *R. kielmannsegi* recalls the habitus of *R. melanostoma*, as was already pointed out by Zelebor. Some time back I found at Takapuna and Narrow Neck young live shells of *Astralium sulcatum*, subsp. *davisii*, and comparing these with the specimens of *R. kielmannsegi* I found them to perfectly agree. Whenever a specimen with the calcareous operculum was found it was thrown away again, every conchologist recognising at once that it was only a young *Astralium*, and they were never carefully compared with the dead shells of the supposed *Risella*.

The genus *Risella* has therefore to be omitted from the list of New Zealand *Mollusca*. The Pliocene *R. melanostoma*, however, is undoubtedly that species, now extinct in New Zealand.

Analthea hexagona, n. sp.

Hipponyx cornucopiæ, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 32 (not of Lamarck). *Hipponyx australis*, Hutton, Journ. de Conch., vol. xxvi, 1878, p. 30 ; Man. N.Z. Moll., 1880, p. 88 ; Proc. Linn. Soc. N.S.W., vol. ix, 1884, p. 939 (not of Lamarck).

This species differs from *H. australis*, Lamk., in the more or less distinct hexagonal, rarely pentagonal, outline of the aperture. The interior has a light-green central area, which is cinereous or brown in *australis*, and the margin is light-purple. The radiate riblets, similar to those of *australis*, are mostly visible only on young specimens ; adult shells are strongly corroded, but incremental lines are sometimes visible. The greatest diameter of the aperture of my largest specimen is 22 mm. ; the altitude is extremely variable.

Hab.—A rock in Tauranga Harbour, and Chatham Islands.

Type in my collection.

Calyptræa novæ-zeelandiæ, Lesson (1830).

Crepidula (*Sigapatella*) *novæ-zeelandiæ*, Lesson, Voy. de la " Coquille," Zool., vol. ii, 1830, p. 395. *Calyptræa maculata*, Quoy and Gaimard, Voy. Astrol., Zool., vol. iii, 1835, p. 422, pl. lxxii, figs. 6–9.

The name of Quoy and Gaimard being used by the majority of conchologists made me quite forget that Lesson's name has priority. Although his diagnosis was not accompanied by a figure it is quite sufficient to identify the species.

Calyptræa (Calyptropsis) alta, Hutton (1885).

Trochita alta, Hutton, Trans. N.Z. Inst., vol. xvii, 1885, p. 329. *Calyptræa alta*, Hutton, Pliocene Moll. N.Z., in Macleay Mem. Vol., 1893, p. 62, pl. vii, figs. 59, *a*, *b*.

There are three convex rapidly increasing whorls, ornamented with well-marked rugose growth-lines ; colour light-brown ; aperture rotundate-oval ; septum sinuated near the false columella ; the interior whitish-brown, light-brown radiate bands are sometimes to be found on the septum ; subperforate, only a small chink being left. Diameter : maximum, 32 mm. ; minimum, 29 mm. Altitude, 23 mm.

It will be seen that the recent specimens are larger than the fossil ones (25 mm. by 16 mm.).

Hab.—A number of specimens, mostly with broken septum, were collected by Mr. McGahey, former lighthouse-keeper at Cape Maria van Diemen, and most obligingly presented to me.

Rissoa zosterophila, Webster (1905).

Rissoia (*Sabanæa*) *annulata*, Suter, Proc. Mal. Soc., vol. iii, 1898, p. 63; Index Faunæ N.Z., 1904, p. 77 (not of Hutton). *Rissoia zosterophila*, Webster, Trans. N.Z. Inst., vol. xxxvii, 1905, p. 277, pl. ix. figs. 5, *a*, *b*.

I remember that many years back when I began taking an interest in marine shells I found a small *Rissoa* in Lyttelton Harbour, which I took for Hutton's *R. annulata*, misled by the pale band below the suture. Through the kindness of Professor Chilton, Acting Curator of the Canterbury Museum, I have now been able to see the type of *Rissoia annulata*, which is simply a variety of *Rissoina olivacea*, Hutton. Everybody who has had to do with these minute shells knows how easy it is to make a mistake if specimens are not actually compared. I am much indebted to the Rev. Mr. Webster for clearing up this error.

Rissoina (Eatoniella) limbata, Hutton (1883).

Cingula limbata, Hutton, N.Z. Journ. Sci., vol. i, 1883, p. 477; Trans. N.Z. Inst., vol. xvi, 1884, p. 214. *Rissoa limbata*, Hutton, Proc. Linn. Soc. N.S.W., vol. ix, 1884, p. 941; Tryon, Man. Conch. (1), vol. ix, 1887, p. 355, pl. lxxi, fig. 98. *Phasianella limbata*, Suter, Proc. Mal. Soc., vol. iii, 1898, p. 8; Index Faunæ N.Z., 1904, p. 8. *Rissoina* (*Eatoniella*) *limbata*, Webster, Trans. N.Z. Inst., vol. xxxvii, 1905, p. 278, pl. x, figs. 8, 8*a* (dentit., operc.).

Type, from Auckland, in the Canterbury Museum.

It is very fortunate that the operculum and dentition of this species were examined by Webster, and the generic position settled beyond a doubt. When I transferred the species to *Phasianella* I had only a single specimen, obtained near Sumner, which had the operculum deep in the aperture fixed on the animal, and I did not try to extract it. I examined the specimen again and found the operculum white and having a calcareous appearance. The same peculiarity I observed in Auckland specimens, but on extracting the operculum all the white colour had disappeared, and it was horny, with a claviform process as figured by Webster. There is no doubt that I was misled by the whitish tissue of the animal showing through the semitransparent operculum.

Turritella carlottæ, Watson (1880).

Turritella carlottæ, Watson, Journ. Linn. Soc., Zool., vol. xv, 1880, p. 222; "Challenger" Reports, vol. xv, Gastropoda,

p. 478, pl. xxx, fig. 5. *Turritella vittata*, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 29 (not of Lamarck, used for a fossil shell).

Hutton's name being preoccupied, Watson's name is available. In my opinion the two represent the same species.

Vermicularia (Stephopoma) nucleogranosa, Verco (1904).

Stephopoma nucleogranosum, Verco, Trans. Roy. Soc. South Australia, vol. xxviii, 1904, p. 143, pl. xxvi, figs. 11–13.

About two years ago I found this species at Takapuna on the under-side of boulders between tide-marks. On examining it I found it to be a new species, and put it aside foı future description. My specimens quite agree with Dr. Verco's excellent description and figures. The setæ of the operculum show a very great variability, and they are quite distinct from the symmetrically built setæ of *V.* (*Stephopoma*) *rosea*, Q. and G.

Planaxis mollis, Sowerby (1823).

Buccinum brasilianum, Lamarck, Anim. s. vert., vol. vii, 1822, p. 272. *Planaxis mollis*, Sowerby, Genera, paıt xii, 1823. *Planaxis brasilianus*, Hedley, Proc. Linn. Soc. N.S.W., 1904, p. 186.

Mr. Hedley has shown that Lamarck's name, though a misnomer, has priority over that of Sowerby. In my opinion it is not in the interest of science to adopt a name distinctly proved to be a misnomeı, and to substitute it for a name accepted by most conchologists.

Tritonium costatum, Born (1780).

Murex costatus, Born, Test. Mus. Cæs. Vindob., 1780, p. 297.

This is the species commonly known as *T. olearium*, L. Hanley has, however, shown that Linné's *Murex olearium*, L., is the same as *Ranella gigantea*, Lamarck. (For full list of references see "Challenger" Report, vol. xv, Gastropoda, p. 390.)

Tutufa (Crossata) californica, Hinds (1844).

Ranella californica, Hinds, Voy. "Sulphur," 1844, p. 12, pl. ii, figs. 4, 5 (= *thersites*, Redfield).

A specimen of this Californian species was found at the Kermadecs, and is in the Auckland Museum. The whole surface of the shell is covered by a white coating of nulliporites. I compared it with a specimen fıom California, and was unable to separate the two. This is another Kermadec puzzle

Columbella inconstans, nom. mut.

Columbella varians, Hutton, Trans. N.Z. Inst., vol. xvii, 1885, p. 314, pl. xvii, fig. 2; Pliocene Moll. N.Z., in Macleay Mem. Vol., 1893, p. 44, pl. vi, fig. 16 (not of Sowerby, 1832). *Surcula varians*, Suter, Trans. N.Z. Inst., vol. xxxi, 1899, p. 69; Index Faunæ N.Z., 1904, p. 71.

Feeling somewhat doubtful about the correctness of my transferring this species to the genus *Surcula*, I sent some fossil specimens to Mr. M. Cossmann, asking him to be good enough and give me his opinion on the subject. He very kindly informed me that Captain Hutton had no doubt correctly classified the shell. I was misled by the shallow sinus on the outer lip below the suture. The specific name applied to it by Captain Hutton being preoccupied, I now propose the above.

Columbella pseutes, nom. mut. Plate XVIII, fig. 10.

Obeliscus roseus, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 22; Journ. de Conch., vol. xxvi, 1878, p. 24; Man. N.Z. Moll., 1880, p. 72; Proc. Linn. Soc. N.S.W., vol. ix, 1884, p. 935. *Pyramidella rosea*, Suter, Trans. N.Z. Inst., vol. xxxiv, 1902, p. 214; Index Faunæ N.Z., 1904, p. 74.

When examining the type specimens in the Colonial Museum I found the columella smooth, no plications being present; the species therefore does not belong to the genus *Pyramidella* (= *Obeliscus*), and its proper place is no doubt under *Columbella*. The specific name being preoccupied in that genus, I suggest the name *pseutes* (the deceiver). The figure is from a type specimen.

The type specimens are from Stewart Island. Examples I found in the Auckland Harbour are purplish-black with a white band.

Cominella maculosa, Martyn (1784).

Buccinum testudineum, Chemnitz, Conch. Cat., vol. x, 1788, p. 187, pl. clii, fig. 1454. *Buccinum maculosum*, Martyn, Univ. Conch., vol. i, 1784, fig. 8.

The name of Chemnitz having to be abandoned as being polynomial, I consulted Mr. Hedley, who is always ready to assist us New Zealand conchologists, as to the name to be adopted. He very kindly sent me tracings of *B. testudineum* and *B. maculosum*, suggesting that both represented one and the same species, and that in consequence Martyn's name could be used. The figures, though representing shells of different size, show the same main characters, and the diagnoses do not point to two different species. I compared specimens from seven localities in New Zealand, and I must confirm Mr. Hedley's view as correct.

Following Captain Hutton's latest publication on the genus, the more ponderous shells with a cinereous columella, as they occur from Cook Strait down to Banks Peninsula, were taken as *C. maculosa*, Mart., but the difference from the Auckland shells, taken for *C. testudinea*, is so slight that they cannot be kept apart as two species. Moreover, the dentition is the same in the two, as will be seen on examining the figures given by Captain Hutton in Trans. N.Z. Inst., vol. xv, pl. xviii, figs. M, N. In fig. M the lateral teeth are turned over, the outer denticles laying over the rhachidian tooth.

Cominella costata, Quoy and Gaimard (1833).

Buccinum costatum, Quoy and Gaimard, Voy. Astrol., Zool., vol. ii, p. 417, 1833, pl. xxx, figs. 17–20. *B. eburneum*, Reeve, Conch. Icon., pl. xii, fig. 93, 1846. *B. angasi*, Crosse, Journ. de Conch., 1864, p. 275, pl. xi, fig. 5.

Two years ago Mr. E. A. Smith, I.S.O., of the British Museum, sent me a specimen which he told me came from New Zealand. I found it to perfectly agree with Quoy and Gaimard's diagnoses and figures, as well as with specimens in my collection from Tasmania, and it has to be added to the list of New Zealand shells.

Cominella zealandica, Reeve (1846).

Buccinum zealandicum, Reeve, Conch. Icon., sp. 28, 1846. *Cominella zealandica*, Tryon, Man. Conch. (1), vol. iii, p. 183, pl. lxxix, fig. 384.

This species is considered as a synonym of *C. maculata*, Mart., by Captain Hutton in his Révision des Coq. de la N.-Zélande, 1878, and in Man. N.Z. Moll., but omitted, as not really inhabiting New Zealand, in the " Revision of the Rhachiglossate Mollusca," 1884.

Tryon says, " This species never came from the locality assigned to it ; it is a true *Buccinum*, and may be a form of *undatum*, having accidentally deepened colour upon the superior revolving lines ; or, if the colour is normal, then it is probably a var. of *B. cyanum*, Brug."

My attention was first drawn to this species by a Pliocene shell from Waikopiro, which agrees perfectly (the colouring, of course, excepted) with Reeve's diagnosis and figure. I also have a recent specimen from New Zealand, yellowish, the revolving lines between the ribs brown-tinted, in my collection.

This species and *C. costata* are nearly allied to the Australian *C. lineolata*, Lamarck, and may have been the cause for including the latter species in our fauna. However, I have never found or seen a New Zealand specimen of *C. lineolata*, and we may safely omit it from the list of New Zealand molluscs.

Nassa zonalis, A. Adams (1852).

Proc. Zool. Soc., 1851, p. 107 (publ. 1852).

Specimens were collected at the Kermadec Islands by Miss Robison, of Christchurch, and I am again indebted to Professor W. H. Dall for naming them. They are much worn, and it may well be that these, and perhaps several other species that have been found washed up on the beach, were carried down on seaweeds by currents from a northerly direction. It seems most desirable that one or several good collectors should stay at the Kermadecs for several months and thoroughly investigate the interesting fauna of that group, including dredging. For the present all we can do is to put on record all the species found in the locality, leaving it to future workers to weed out the species not really living in the group. Dead specimens of *Conus* and *Cypræa* have also been found at the Kermadecs.

Purpura striata, Martyn, n. subsp. bollonsi.

This subspecies may shortly be described as a *P. striata* in which the revolving cinguli are cut up by more or less deep longitudinal sulci into distinct nodules, thus producing the sculpture of *P. emarginata*, Desh. The colour of the shell and interior of mouth is white, and the outer lip is strongly denticulated. These two latter characters distinguish it from *emarginata*, which, if really found in New Zealand, may be a form of *P. squamata*, Hutton.

Hab.—This very pretty subspecies was collected by Captain Bollons, of the "Hinemoa," at the Kermadec Islands. Captain Bollons is well known as a most enthusiastic collector, doing all in his power to further the interests of science, and I propose to name the subspecies in his honour.

Type in my collection.

Marginella albescens, Hutton (1873).

Marginella albescens, Hutton, Cat. Mar. Moll. N.Z., 1873, p. 19; Journ. de Conch., vol. xxvi, 1878, p. 22; Man. N.Z. Moll., 1880, p. 62. *M. infans*, Hutton, Trans. N.Z. Inst., vol. xvi, 1884, p. 224 (not of Reeve).

Hutton's name originally given to the species has to be adopted again, as our shell is not the same as Reeve's *infans*, which occurs near Singapore. No doubt Captain Hutton followed Tryon in identifying his species with that of Reeve. Further, *M. pellucida*, T.-Woods, is not a synonym of *infans* or *albescens* either.

Ancilla rubiginosa, Swainson (1840).

Ancilla rubiginosa, Swainson, Zool. Illustr., vol. ii, 1840, pl. iv; Tryon, Man. Conch. (1), vol. v, p. 94, pl. xxxvii, fig. 25, pl. xxxviii, figs. 26, 27.

A. mammilata, Hinds, and *A. albo-callosa*, Lischke, are synonyms. Specimens I collected near Timaru and Sumner were kindly named by Professor W. H. Dall. My largest specimen has an altitude of 30 mm. According to Tryon the habitat of the species includes Japan, China, Malacca, and Madagascar.

Ancilla lata, Hutton (1885).

Ancillaria lata, Hutton, Trans. N.Z. Inst., vol. xvii, 1885, p. 325; Pliocene Moll. N.Z., in Macleay Mem. Vol., 1893, p. 44, pl. vi, fig. 15.

Specimens were found in the Manukau Harbour by Mr. C. Spencer and the Rev. Mr. Webster, and I also not unfrequently came across the species in the Hauraki Gulf. The specimens from the latter locality exactly correspond with a small form found in the Pliocene near Waikopiro

Terebra venosa, Hinds (1844)

Terebra venosa, Hinds, Proc. Zool. Soc., 1843, p. 157 (publ. 1844). *T. penicillata*, var. *venosa*, Tryon, Man. Conch. (1), vol. vii, p. 13, pl. xi, figs. 12, 13.

Specimens were also collected by Miss Robison at the Kermadecs, and kindly identified by Professer W. H. Dall (not by myself, as stated by the Rev. Mr. Webster). Tryon gives as habitat—Seychelles, Mauritius.

Daphnella cancellata, Hutton (1878).

D. cancellata, Hutton, Journ. de Conch., vol. xxvi, 1878, p. 18; Man. N.Z. Moll., 1880, p. 45. *D. lymneiformis*, Hutton, Proc. Linn. Soc. N.S.W., vol. x, 1885, p. 118; Suter, Trans. N.Z. Inst., vol. xxxiv, 1902, p. 211; Index Faunæ N.Z., 1904, p. 71 (not of Kiener).

I have never seen *D. lymneiformis*, Kiener, but Mr. Hedley informs me that our shell is not Kiener's species, and we have therefore to fall back on Hutton's name.

Hab.—The type is from Auckland. I have also specimens from Stewart Island, which are much smaller—length, 7·5 mm.

Type in the Otago Museum, Dunedin.

Polypus campbelli, E. A. Smith (1902).

"Report on the Collections of Natural History made in the Antarctic Regions during the Voyage of the 'Southern Cross,'" 1902, vii, Mollusca, by Edgar A. Smith, F.Z.S., p. 201, pl. xxiv, figs. 7–11.

The specimen described is a male. Mr. Smith mentions that the right dorsal arm is shorter than the left, probably bitten by a fish or crustacean. I have a female specimen, also from Campbell Island, which shows the very same peculiarity, and proves that it is not accidental, but must be considered as characteristic of the species.

EXPLANATION OF PLATE XVIII.

Fig. 1. *Chiton huttoni*, Suter. Natural size.
Figs. 2–4. ,, ,, Head, median, and tail valves; enlarged.
Fig. 5. ,, ,, Side view of tail-valve: enlarged.
Fig. 6. ,, ,, Girdle-scales, much magnified.
Figs. 7–9. *Helcioniscus mestayeræ*, Suter. Natural size.
Fig. 10. *Columbella pseutes*, Suter. Photo from type.

ART. XXXIX.—*Genus* Isidora: *Correction of Article XVI. in Last Year's Transactions* (*Volume XXXVII*).

By HENRY SUTER.

[Plate XIX.

THROUGH an unfortunate mistake the figures of *Isidora* species in the text are inversed, representing dextral instead of sinistral shells. The editor, Mr. A. Hamilton, very kindly consented to have them reprinted, showing the correct sinistral volution of the whorls.

EXPLANATION OF PLATE XIX.

Fig. 1. *Isidora tabulata*, Gould.
Fig. 2. ,, ,, ,, subsp. *moesta*, H. Adams.
Fig. 3. ,, *hochstetteri*, Dunker.
Fig. 4. ,, *novæ-zelandiæ*, Sowerby.
Fig. 5. ,, *antipodea*, Sowerby.
Fig. 6. ,, *lirata*, Tenison-Woods.
Figs. 7, 8. ,, ,, ,, subsp. *conferta*, Suter.

Art. XL.—*On* Flabellum rugulosum, *Tenison-Woods.*

By Henry Suter.

[*Read before the Wellington Philosophical Society, 4th October,* 1905.]

Flabellum rugulosum, Tenison-Woods, "Palæontology of New Zealand," part iv, "Corals and Bryozoa of the Neozoic Period in New Zealand," 1880, p. 12, figs. 8, *a*, *b*

Captain J. Bollons, of the Government steamer "Hinemoa," dredged living specimens of this fine coral in 50 fathoms between Cuvier and Mokohinau Islands, and very kindly presented me a specimen. Unfortunately, the animal had already been removed, but Captain Bollons told me that it was beautifully banded with white and scarlet. My example agrees in every particular with specimens from the Pliocene of Wanganui, but it is larger than any I have seen. Altitude, 44 mm.; axis, 60 mm.; min. axis, 20 mm.

This interesting addition brings the number of New Zealand species of the genus up to two, *F. rubrum*, Q. and G., being the other species. This latter is not uncommon on rocks at low-water mark in Hauraki Gulf, and is very conspicuous by its scarlet animal. Unfortunately, in alcohol the colour is completely lost.

Art. XLI.—*Notes on Insect Swarms on Mountain-tops in New Zealand.*

By G. V. Hudson, F.E.S

[*Read before the Wellington Philosophical Society, 2nd August,* 1905.]

At a recent meeting of the Entomological Society of London, the president, Professor Poulton, F.R.S., read a short paper entitled "A Possible Explanation of Insect Swarms on Mountain-tops," in which he suggested as probable that "certain species of insects with powerful flight, after reaching the imaginal state, have the instinct to seek conspicuous isolated features in the landscape; that in others with smaller powers or unable to fly the instinct is merely to ascend. The effect of both tendencies is to reduce the area over which the sexes have to find each other. A somewhat deferred maturity, and the gradual collection of scattered individuals into swarms, is probably associated with the instinct in many cases, facilitating still further the meeting of the sexes and the pairing of individuals from remote areas. It is obvious that the gathering swarm will be far more easily seen than single insects by the scattered individuals around. The swarming of beetles, &c., round tree-tops is probably to be thus explained. Related to the same combination of instincts preparatory to pairing is the driving-off of the winged males and females of ant communities, in response to probably some atmospheric stimulus which makes itself felt on a single day over a vast area." In connection with these general deductions by Professor Poulton, it has occurred to me that the few observations of the kind made by myself on New Zealand insects should perhaps be placed on record in the Transactions, especially as the perusal of these brief notes may possibly lead others to make fuller and more complete observations of a like nature.

On the 12th December, 1886, I observed on the highest hill to the south of Wellington Harbour great numbers of one of our commonest beetles, *Pyronota festiva*, together with a swarm of a common fly, *Bibio nigrostigma*. These insects were not numerous elsewhere, but were only abundant on the top of the hill.

On the 9th January, 1893, I observed on the rocks and stones on the top of Mount Enys, near Castle Hill, at an elevation of about 7,200 ft., a large swarm of ladybirds (*Coccinella 11-punctata*). There was no vegetation here which could have afforded food for aphides, and as ladybirds feed exclusively on aphides the inference is that the insects must have migrated to this high and inhospitable peak under the influence of some powerful instinct.

On the 22nd February, 1903, I observed vast swarms of *Pyronota festiva* flying over the birch-trees at the bush-line on one of the western slopes of Mount Earnslaw, at an elevation of about 4,000 ft. The afternoon was extremely hot, and the flight of the insects so rapid that I did not recognise them as beetles until after I had netted a few specimens for examination. The beetles must have been present in countless thousands, as they were swarming round the birch-trees and apparently equally abundant at all points along that slope of the mountain where I was collecting.

I have frequently observed the phenomena of ant-migrations mentioned by Professor Poulton, although I am only able to give three actually recorded instances. These cases prove, however, that the winged male and female ants were being ejected by the worker ants over very extended areas at the same time. It is probable that the flight of these vast swarms of winged ants gives rise, to a great extent, to that humming in the air frequently noticed on very hot calm days towards the end of summer, and specially mentioned by Gilbert White in his "Natural History of Selborne."

On the 1st April, 1888, whilst collecting on the hills around Kilbirnie, I noticed that a great flight of the winged males and females of *Aphænogaster antarctica* was in progress. All the spiders' webs were full of the males, and numerous specimens of both sexes were found crawling on fences and about the ground. The ants were noticed over an area of fully two miles, but there is no reason to think that the swarming was confined to the country then traversed.

On the 31st March, 1889, I again observed this ant-swarming, this time over an extensive tract of hilly country to the south of Wellington. The ants were so abundant as to be almost intolerable to persons walking. The weather was very hot, calm, and sunny on both occasions.

On the 28th February, 1892, another very hot day, I observed, at Karori, swarms of the winged individuals of *Aphænogaster antarctica*. The "humming in the air" was very evident on this occasion, and was no doubt produced by the vast numbers of ants flying overhead.

Closely allied to the foregoing instincts is that of so-called "gregarious hibernation," which appears to occur in one of our common ichneumon flies, *Degithina buchanani*, but in this species it seems to be the females only which are thus found congregating. The following observations, made in 1883, have since been frequently repeated. In fact, as recently as May, 1903, I found these insects hibernating in large numbers between the weatherboards of my little observatory at Karori. On the 14th January, 1883, I observed, whilst collecting at Karori, a number of specimens of this fine ichneumon fly flying in and out of a crack in the bark of a large matai-tree. Being desirous of discovering what attracted them, I removed a large portion of the bark, and found that there were over sixty insects crowded together in the hollows and irregularities underneath. I captured several and examined a great number of them, and found them to be all females, there being no difficulty in at once determining the sex in this species. There was no nest of any kind in the tree, the cavity being merely a natural one, the ichneumon flies not having improved on it in any way. On the 3rd June of the same year I found a number of these insects under exactly similar circumstances, in the forest about five miles from Palmerston North. There were about a hundred specimens, and they were all females, and seemed quite torpid, this being due, no doubt, to the cold season of the year. On this occasion there were, of course, no specimens on the wing.

ART. XLII.—*Notes on some South Island Birds, and Maori Associations connected therewith.*

By J. COWAN.

[*Read before the Wellington Philosophical Society, 18th November,* 1905.]

WHILE in the extreme south of the South Island this year. engaged in collecting historical Maori matter from the very few well-informed Natives who have survived to these days, I gathered one or two notes regarding certain southern birds which may be of some interest, seeing that the particulars have not hitherto been placed on record. My chief informants were members of the Ngaitahu Tribe living at Colac Bay (or Oraka), on the shores of Foveaux Strait—elderly men who have been sealers and bird-hunters for the greater part of their lives, and who are more reliable on matters of natural history and bush-craft than the other southern Natives. They are also in part descended from the ancient Ngatimamoe, who ceased to exist as a tribe probably over a century ago.

My first note refers to the *Notornis mantelli*, the *rara avis* called by the Maoris the "*takahea*." The name of this bird is spelled "*takahe*" in Buller's "Birds," and all other works in which it is mentioned. The Maoris inform me that this is wrong; there should be a final *a*, as I have spelt it here. The *takahea* is undoubtedly the most interesting of all our native birds; it has almost, if not quite, vanished from existence. The last-known living specimen was captured in 1898 on the shores of the Middle Fiord of Lake Te Anau. It is possible that a few specimens of this most ancient of feathered creatures may still roam the great forests of Fiordland, between Te Anau and the west coast. It is not necessary here to describe the bird further than to say that it is not unlike a *pukeko* or swamp-hen in general appearance and plumage, that it has short wings useless for purposes of flight, but armed below the carpal joint with a sharp spur or claw, and that it has a very strong and peculiarly arched red bill.

In former times, according to Te Paina and Kupa Haereroa, of Colac Bay, *takahea* were plentiful around the shores of Lakes Te Anau and Manapouri, and the Southland Maoris were accustomed to make annual expeditions for their capture. At this period the shores of these great lakes were inhabited by the Maoris, and villages stood at a spot called Owhitianga-te-ra (the Place of the Rising Sun), at the foot of Te Anau, at the points where the Waiau River enters and leaves Manapouri, and elsewhere in the vicinity. Some of the numerous wooded islands in Manapouri were also favourite camping-places of the Maoris, who snared birds in the woods, caught wild ducks in the lagoons, and fished for eels by torchlight in the sandy bays, spearing them with the wooden triple-pronged *matarau.*

In winter the *takahea* were driven down from the mountains by the snows, and they were then found around the shores of the lakes, feeding chiefly on the sweet swamp-grass *pouaka.* One of the spots much frequented by the bird, according to the Murihiku Maoris, was a lagoon (or *hapua*) known as Te Wai-o-Pani, on the south-west shore of Te Anau. This lagoon is backed by a high cliff, on the top of which is a plateau with a *pakihi* or natural clearing, rich in fern-root, one of the food-staples of the olden Maori. This clearing, a perfect and safe retreat for a broken tribe, is said to have been one of the Ngatimamoe places of refuge when that unfortunate tribe was almost exterminated by Ngaitahu, and the remnant driven into the vast forest wilderness of Fiordland, called by the Maoris Te Rua-o-te-Moko, where they finally became extinct. The *pakihi* was accessible only by a very precipitous route up the face of the cliff. The white man, say the old people of Murihiku, has not yet discovered this well-hidden spot. Here the *takahea* was sometimes found. It was hunted with dogs, and when attacked showed vigorous fight. It would strike out with its feet and bite with its strong short beak, hissing like a bittern. The Natives describe its resonant metallic night-cry as resembling the sound made by two pieces of greenstone when sharply struck together.

Another remarkable flightless bird, fortunately not so scarce as the *takahea,* is the member of the *Apteryx* family commonly called by naturalists the "*roa.*" The Maoris say that the proper name of this bird is the "*tokoweka.*" The *tokoweka* is now plentiful on Resolution Island (Taumoana), the Government avifauna sanctuary in Dusky Sound.

Of our summer visitors the migrant *pipiwharauroa,* or shining cuckoo, is particularly well known to the southern Maoris. The *pipiwharauroa* is, of course, not confined to the South Island; it is famous amongst the Maoris all over the colony, but particularly on the coasts. It arrives with its South Sea Island cousin the long-tailed cuckoo (*koekoea*) about October, and leaves our shores again for its winter quarters in northern Australia and New Guinea about the end of February. Like the English cuckoo, the *pipiwharauroa* is regarded as the harbinger of spring. The Southland Natives call it "Te Manu-a-Maui" (Maui's Bird), because its notes when heard in the spring are a signal to begin the planting—Maui being the tutelary deity of the gardens and cultivations. Its sweet and frequently repeated notes, heard oftenest around the seashore and in the coppices which compose the outer fringes of the forest, are sometimes interpreted by the Maoris as "*Ku-i, ku-i! Whiti-whiti ora!*" concluding with a long "*Tio-o!*" "*Whiti-whiti-ora*" may be translated as meaning "safely crossed," in allusion perhaps to the bird's safe arrival after its long flight across the ocean. Its song is also construed as a command to the *kumara*-planters—

> Ko-o-ia, koia, koia;
> Tiria, tiria, tiria;
> Whatiwhatia, whatiwhatia

bidding the people dig away, break up their mother earth and prepare the soil for the reception of the seed *kumara.*

There is a very ancient planting-song called "Te Tewha-o-Maui" ("The Chant of Maui"), used on the occasion of *kumara*-planting in the Hot Lakes District, particularly on the Island of Mokoia, in Lake Rotorua. It is rather curious to find that a portion of exactly the same song is heard in the extreme south, where the Murihiku Maoris put it into the mouth of the *pipi-wharauroa.* Legend says that it was from Maui (who was credited with being able to effect remarkable "lightning changes," after the manner of the heroes in the "Arabian Nights") that the Maori ancestors first heard the *kumara*-planting incantations. The demi-god transformed himself into a bird and sang this *tewha* as he sat perched on the handle of a *ko* or digging-implement. So that this song (which is too long to quote here) was brought from the old home of the Maoris in the islands of Polynesia, and is therefore of great antiquity.

Straying again for a moment to the North Island—there is a Maori monthly newspaper published at Gisborne called the "*Pipiwharauroa*" after this interesting bird. Its Maori correspondents take poetic flights that are quite in keeping with the name of the journal. They address the paper as "My dear little bird," and enjoin it to bear their words all over the Island upon its wings. And the editor, too, is not without poetry in his soul, for he heads his list of subscribers (sadly dilatory ones, I am sorry to see) with the words "*Nga hua kareao mo ta tatou manu,*" which means "Supplejack-berries to feed our bird."

A beautiful bush-musician in the South Island—which we unfortunately seldom or never hear in the North—is the bell-bird (*korimako* or *makomako*). In Otago, Southland, and Stewart Island the Natives call it the "*koparapara.*" It is very delightful to a bird-lover from the North Island to note the plentiful numbers and the tameness of the bell-bird in such places as Akaroa (where it has developed a taste for *pakeha* plums and pears and cherries, and for the flowers of the *Acacia*), and in most of the wooded parts of Otago, Southland, and Stewart Island.

A strange bird in Maori eyes is the *hakuai* of the off-shore islands in the far south. The Natives of Foveaux Strait and Stewart Island sail off in March and April every year to the craggy islets near the rugged west coast of Stewart Island for their annual mutton-bird harvest, and it is there that they meet with the *hakuai.* Whole families go mutton-birding—men, women, and children—and camp on the islands for some weeks. At night the fowlers gather round their camp-fires, and old songs are sung and folk-tales and ghost-stories retold. And in the darkness sometimes they hear the ghost-bird screaming its "*Haku-ai, haku-ai, Ooh!*" and then a hair-raising swoosh of great wings as some mysterious creature of the crags sweeps past them into the night, crying as it goes. This bird, called the "*hakuai*" from its cry, is spoken of as a spirit. To see it is an evil omen; it is the banshee of the islands. The Maoris say it has been frequently heard on Herekopare or Mummy Island, which lies off the entrance to Paterson Inlet, and on the islands off the south-west cape of Stewart Island. One is reminded of Blackmore's description of the moorland birds in "Lorna Doone" "—Vast lonely birds, that cried at night and moved the whole air with their pinions, yet no man ever saw them"—and again of the *hokioi* of North Island legend, the great war-bird of which the song says—

> Two fathoms long are its pinions;
> Its wings make a booming noise.
> It lives in the open space of heaven,
> The companion of the crashing thunder.

The mystery of the *hakuai* may be dispelled by assuming it to be—as it no doubt is—the frigate-bird (*Fregata aquila*). The wings of these lords of the seas have a great spread.

The *kotuku*, the beautiful white heron or crane, so famous in Maori poetry and proverb, is still to be found in one or two parts of the South Island. It is many years since one was seen in the North. It is said that there are some stray *kotuku* occasionally to be seen in the southern bays of Stewart Island. But the only place to my own knowledge where this rare species yet exists is in the Okarito Lagoon, a labyrinth of tidal creeks and sandbanks and small islands down on the West Coast, about ninety miles south of Hokitika. This lagoon swarms with all kinds of waterbirds and waders, and amongst them are some white herons. One of these birds is frequently seen, and ventures right into the Okarito Township. He is often observed fishing in stately solitude in a little pond just at the back of the local hotel; and he seems to know he is safe—no gun is ever raised against the white spirit-like bird of the lagoon. Certainly there is little to disturb him in Okarito—the very "deadest" of all the dead "boom" towns of the old digging days. The southern Maoris say that the *kotuku* is an inhabitant of the nether world, the spirit-land of the *Reinga*. An old funeral lament ends with these words, in apostrophe to the departed: "*Ko te kotuku to tapui, e Tama—e!*" ("The white heron is now thy sole companion, O my son!")

The beautiful onomatopoetic Maori names of many New Zealand birds have no doubt been remarked upon by some of our nature-lovers. A considerable number of our indigenous birds derive their names from their cries and songs. To enumerate a few, there are the *kuku* (or pigeon), the *koko* (or *tui*, the parson-bird), the *kaka* parrot, the *hakoakoa* (seabird), the *whio* (blue mountain duck), *kea* (mountain parrot), and the *riroriro*, the little grey warbler. One can readily understand how these names came to be given, particularly in the case of the wild pigeon; *ku-ku* is simply an imitation of the sound uttered by the bird as it flaps from tree to tree, or sits up in the branches feasting on the berries—literally a "coo," the softest, most loving of forest calls. The *whio*, or "whistler," generally called the blue mountain duck, is much more abundant in the South Island than the North, and is to be seen at particularly close quarters on such routes as the foot-track leading through the mountains from Lake Te Anau to Milford Sound. Here, in many of the clear pools and calm reaches on the Clinton River, you will see little fleets of *whio* sailing round and round, uttering now and then the peculiar cry, like a whistle with a cold in it, that has gained for them their Maori name. They have never learned to fear man or his gun, and their confidence and tameness are pretty to see. Finally, there is the *kea*, the remarkable alpine parrot, the outlawed of squatterdom. Far up in the mountains, in the wastes of rock and ice, the *kea*'s scream will be heard, as he circles round you on the cliffs, or hops across the surface of the glacier after you—for he is as inquisitive and impudent as the *weka*—yelling "Kay-ah! kay-ah!" at you at the top of his voice.

ART. XLIII.—*On a Specific Case of Leaf-variation in* Coprosma baueri, *Endl.* (Rubiaceæ).

By L. COCKAYNE, Ph.D., Cor.F.B.S.Ed.

[*Read before the Philosophical Institute of Canterbury, 6th September*, 1905.]

Plate LII.

Coprosma baueri is a common New Zealand shrub or small tree frequently occurring in exposed situations on the North Island coast. It also extends to the South Island, having its southern limit in the west of Nelson. It is found, too, in Norfolk Island, but whether the form there is identical with the New Zealand plant appears to be somewhat doubtful.* When growing on cliffs and rocks it is frequently prostrate, being flattened closely against the rock-surface, but when in more sheltered situations and in deeper soil it is a small tree with a fairly thick trunk and dense crown of foliage; in fact, the two extreme forms are so unlike that they might easily be mistaken for two different species. It is most amenable to cultivation, and in consequence is very frequently made use of as a hedge plant in many parts of New Zealand, especially in the North Island. Now, as in many cases such hedge plants are growing under conditions different from those of the species in its natural seaside habitat, an opportunity is afforded of instituting a comparison between the cultivated and wild plants. Thus, during my recent residence at Island Bay, Wellington, I had an opportunity to observe such differences as existed between the leaves of a certain shelter hedge in that neighbourhood and those of plants growing near the sea, both of the tree and prostrate forms.

The hedge in question was so planted, between a paling fence on the one side and a house on the other, that it was sheltered in its lower part from the north-west wind, and altogether from that from the south-west, these two winds being, as is well known, extremely severe in the above locality. Moreover, the basal portions of the plants were in almost complete shade, receiving little, if any, direct sunlight.

In contradistinction to this wind-still, shady environment, that of the seaside plants is very different. There they are exposed to frequent and furious winds and to bright, direct sunlight. Some plants also may receive at times a certain amount of sea-spray, which of course will tend to increase the succulence of their leaves.

A glance at the photograph (Plate LII) shows at once the great difference which exists between such shade leaves and those exposed to sun and wind, which latter, however, belong to the normal leaf-form of the species. To go into further details, the leaves of *Coprosma baueri* when growing in its natural habitat are somewhat fleshy in texture, glossy green on the upper surface but much paler beneath, and the margins are recurved.

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* Thus, Hooker writes, "The New Zealand specimens are much more succulent and stout in habit than those of the Norfolk Island, but I find no differences in the flower or fruit" ("Flora Novæ-Zelandiæ," vol. i, p. 104).

Maiden ("The Flora of Norfolk Island," Proc. Linn. Soc. N.S.W., 1904, p. 706) did not observe *Coprosma baueri* during his visit to Norfolk Island, and considers that it is probably rare.

This latter character is frequently carried to such a pitch that each half of the blade is rolled round itself, or the one half may be rolled round the other, the leaf thus presenting the appearance of a pipe. Such leaves may be called "rolled leaves." As for the dimensions of the leaves, the following are taken from Island Bay coastal plants:—(1) Leaves of the tree (laminæ): 3·2 cm. by 1·9 cm.; 4·4 cm. by 2·4 cm.; 4·5 cm. by 2·2 cm.; 3·1 cm. by 1·8 cm.; 2·8 cm. by 1·6 cm.; 5 cm. by 2·8 cm.; 2·7 cm. by 1·5 cm. (2.) Leaves of the prostrate shrub (laminæ): 4 cm. by 3·1 cm.; 4 cm. by 2·8 cm.; 3·4 cm. by 2 cm.; 3·8 cm. by 2·3 cm.; 3·1 cm. by 2 cm.; 4·3 cm. by 2·9 cm.; 5 cm. by 3·3 cm.; 2·6 cm. by 1·7 cm. From the above figures it will be seen that there is not much difference in size between the leaves of the prostrate shrub and those of the tree; perhaps, if a considerable number of measurements were taken, the prostrate plant, owing to the superior shelter from wind provided by its habit of growth, would show a larger average leaf-surface.

Turning now to the shade leaves of cultivated plants, some of which it must be pointed out belonged to semi-sucker shoots, they are much larger, slightly thinner, and not quite so glossy as the leaves of normal coastal plants. Actual measurements of various laminæ read: 12·3 cm. by 9·7 cm.; 11·8 cm. by 8·5 cm.; 11·3 cm. by 8·8 cm.; 12·8 cm. by 10·1 cm.; 10·1 cm. by 7·9 cm. Leaves from certain other shade shoots are not quite so large, but still are much larger than the normal—for example, the following: 6·5 cm. by 5·9 cm.; 8 cm. by 4·9 cm.; 6·5 cm. by 5·8 cm.; 6·9 cm. by 6·1 cm. From the above it may be seen that the shade leaves, especially when belonging to suckers, are frequently more than three times the size of normal sun-and-wind leaves, *and that they are always flat*, whereas *the latter have always recurved and frequently rolled leaves.*

Ordinary *Coprosma* hedges, such as are so common in the City of Wellington, are especially instructive for purposes of comparison, since they show all degrees of leaf-form from flat leaves to those with considerably recurved margins. Generally speaking, such hedges occupy more sheltered positions than plants near the sea, and this shelter is frequently enhanced by the hedge being on the lee side of a wooden fence of some kind or another. In such hedges the leaves near the base are more or less flat, becoming gradually more recurved towards the summit of the plant, where they are exposed to the wind. Even the uppermost parts of plants of considerable size, if sheltered from the prevailing winds, may possess some flat leaves. Such hedges, moreover, possess few rolled leaves of an extreme type, but are intermediate in character, so far as leaves are concerned, between shade leaves and normal sun-and-wind leaves.

Whether in the case of *Coprosma baueri* a leaf having once become possessed of a recurved margin can again become flat, or an extreme rolled leaf unroll itself, is a matter requiring investigation. It seems to me, however, that there is a strong tendency in the plant to produce recurved leaves, and that such under normal conditions are characteristic of the species. Seedlings have flat leaves, but there is sometimes a trace of recurving, especially at the base of the lamina. As for the leaves of semi-sucker shoots referred to above, their being flat might in part be attributed to their being reversion-shoots, since such are especially wont to make their appearance at the bases of plants. The large size of such leaves may also in part be due to the well-known luxuriant growth of suckers. All the same, many of the shoots observed were clearly not suckers, and there is no doubt but that shade and absence of wind played a most important part with regard to the leaf-form.

Of course, the rolling of a leaf and consequent reduction of leaf-surface in a xerophytic station is veiy beneficial for the well-being of the plant, but that such is a benefit is no explanation of why such rolling should occur ; it only explains in part how the plant in question can exist in its particular station. On the other hand, the presence of rolled leaves where exposed to sun and wind, and of flat leaves in the shade and in a still atmosphere, points to the wind factor and the light factor, one or both, as having been instrumental in originally causing these structures, which now they are able to evoke, thanks to an hereditary tendency in the plant to respond to their stimulus. Were there no plants of *Coprosma baueri* except those of exposed stations on the coast, then large, flat leaves would be unknown, and the rolled-leaf form would be held to come " true " from seed. Or, again, were there no stations suitable for the tree form, only the prostrate form would exist. That this is not an absurd suggestion is shown by the fact that another New Zealand coastal tree, *Myoporum lætum*, Forst. f., only exists on the Moko Hinou Islands as a prostrate shrub, and were that its sole habitat its power of becoming a tree could never be dreamed of. Such plastic species, indeed, have really no one fixed form, but as Klebs* has shown (if I understand him rightly), their so-called normal characters are merely a few of a larger series, and are of no greater specific value than those others which may be evoked by a different environment.

* " Willkürliche Entwickelungs änderungen bei Pflanzen," Jena, 1903, pp. 145–46 ; indeed, the whole of chapter vii, p. 139 *et seq*, requires consulting.

Another New Zealand plant, *Olearia cymbifolia*, Hook. f., is of interest with regard to the question of flat and recurved leaves. This species is a moderate-sized shrub, and a member of the subalpine scrub of certain mountains in the South Island. Its leaves are small, very hard, thick, tomentose beneath, and *much recurved.* This leaf-form remains quite constant even when the shrub is cultivated at sea-level in good garden soil. But occasionally, from the base of such plants, shoots with flat or almost flat leaves are given off, resembling exactly the adult leaves of a closely allied species, *Olearia nummularifolia*, Hook. f. In this case the recurved leaf is a more stable quantity than is that of *Coprosma baueri*, but the difference is at best one of degree merely, and yet in the case of the *Olearia* is a plant of which the adult was considered by Sir Joseph Hooker, who was certainly no "species-maker," a distinct species,* whilst its basal reversion-shoots† are clearly, if they should flower, *O. nummularifolia*, another of Hooker's species. In such cases as these, and others which could be cited, using only the New Zealand flora, the methods of the systematists appear to break down, and experiment alone can decide as to specific rank.

Before concluding, I wish to express my thanks to Mr. R. Ewing, of Island Bay, and also to Mr. F. G. Gibbs, M.A., of Nelson, who have sent me a large quantity of fresh material, especially seedlings, in connection with this paper.

EXPLANATION OF PLATE LII.

Photograph of shade leaves on left and rolled leaves of seaside plant on right of *Coprosma baueri.* Centimeter scale. Photo by the author.

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* Mr. T. Kirk wrote ("Students' Flora," p. 273): "Var. *cymbifolia* appears to be a depauperated condition largely caused by the ravages of insects." For a long time I was much puzzled how Kirk could have come to this conclusion, but quite recently Mr. F. G. Gibbs sent me some specimens damaged by insects, such as described above. However, such insect-affected plants are quite rare, and the leaf-form of this species does not in the least owe its shape to such a cause.

† I called attention to this phenomenon some years ago in "A Sketch of the Plant Geography of the Waimakariri River Basin" (Trans. N.Z. Inst., vol. xxxii, 1900, p. 123). At the present time I am making certain definite experiments with this plant, which it is hoped may throw fresh light on its variability.

Art XLIV. — *On the Supposed Mount Bonpland Habitat of* Celmisia lindsayi, *Hook. f.*

By L. Cockayne, Ph.D., Cor.F.B.S.Ed.

[*Read before the Philosophical Institute of Canterbury, 6th September*, 1905.]

Among several interesting species of plants discovered by Dr. W. Lauder Lindsay in the course of his visit to Otago in 1861–62 was the very fine *Celmisia* which now bears his name. This plant was especially notable since up till comparatively recent years it was supposed to be confined to that limited area of the south-east Otago coast where Lindsay had first collected it, although the genus is essentially alpine and subalpine. However, some years ago, Mr. Henry J. Matthews, whose important botanical explorations in the Otago lake district and elsewhere have added many valuable facts to New Zealand botany, brought from the Humboldt Mountains, of which Mount Bonpland is the principal peak, a *Celmisia* much resembling *C. lindsayi*. Also, the late Mr. W. Martin, of Fairfield, whose fine collection of alpine plants is well known, had collected in the same region a *Celmisia*, evidently most closely resembling *C. lindsayi*, which Mr. J. Buchanan published in 1888 under the name of *Erigeron bonplandii*,* that botanist having come to the conclusion that the suffruticose *Celmisias* should be united to *Erigeron*.†

That alpine plants frequently occur at sea-level is well known, while several species of *Celmisia* also occur in the lowlands. Such are *Celmisia longifolia*; *C. petiolata*, var. *rigida*,‡ of Stewart Island; *C. verbascifolia*, *C. holosericea*, *C. vernicosa*, of the Southern Islands; while quite recently Mr. A. H. Cockayne and also Mr. H. J. Matthews have collected *C. coriacea* near the sea in north-east Marlborough. Such cases are of considerable phytogeographical interest, which becomes greater where a plant is found only on the coast and in the alpine region but is wanting in the intermediate country.

In 1896 Mr. D. Petrie's most important "List of the Flowering Plants indigenous to Otago"§ appeared, in which the alpine habitat of *Celmisia lindsayi* is mentioned. "I have seen numerous living plants of this species brought by Mr. Henry Matthews, of Dunedin, from the neighbourhood of Lake Harris,"||

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* "On some New Native Plants" (Trans. N.Z. Inst., vol. xix, 1887, p. 213).

† "Description of a New Species of *Erigeron*" (Trans. N.Z. Inst., vol. xvii, 1885, p. 287).

‡ This I consider a distinct species.

§ Trans. N.Z. Inst., vol. xxviii, 1896, p. 540.

|| Lake Harris is in the close vicinity of the Humboldt Mountains.

writes Petrie. Mr. T. Kirk, however, commenting upon this statement, the next year writes, "The reputed Lake Harris station for this fine plant is very doubtful indeed, the plant being purely littoral." Moreover, in the "Students' Flora" Kirk is still more emphatic, stating, "The reported habitats at Mount Bonpland and Lake Harris are erroneous."* To understand Kirk's attitude in this matter one can merely make certain suggestions. He may have considered Matthews's plant as belonging to another species. But this is hardly probable, since Buchanan's *Erigeron bonplandii*, the plant of Martin's garden, and supposed to have been collected by the latter on the Humboldt Mountains, is referred by Kirk to *C. lindsayi*. It seems far more likely that Kirk considered some confusing of localities had taken place, especially as he himself had collected on the Lake Harris saddle and in that neighbourhood. Such a mistake with regard to a plant habitat is a most easy error to fall into when one is collecting largely from all parts of a region, and receiving plants in addition from other sources; and especially easy is it when one is collecting living plants rapidly and not labelling them as collected, but trusting merely to memory. Then, in sorting out, planting, and transplanting, there are additional chances of confusion. Be all this as it may, the above is Kirk's uncontradicted assertion, and until it is proved or disproved there must remain uncertainty as to the very important fact regarding the distribution of *C. lindsayi*.

But the receipt of certain botanical material from Mr. Matthews, together with two explanatory letters, has enabled me to throw some fresh light on the subject. Mr. Matthews thus writes: "In a day or two I will send you specimens of *Celmisia lindsayi*† from Nuggets and *Celmisia* sp. from Mount Bonpland. . . . The flowers certainly do not differ much, but I will ask your opinion on the foliage, &c., which to me appears entirely distinct. Kirk said, as you know, the Bonpland habitat was erroneous; and yet I saw acres of it, and *brought some home a few months ago*." The italics are mine, and that statement entirely removes any suspicion as to "mixing of habitats." There can consequently no longer be a doubt as to the existence of an alpine *Celmisia* closely allied to or identical with the coastal *C. lindsayi*.

The specimens arrived in due course, two living shoots in excellent condition, labelled respectively "Nuggets" and "Bonpland." The following are some notes I made regarding the specimens:—

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* "Students' Flora," p. 284.

† Nugget Point is the original habitat of *C. lindsayi*.

The two shoots bear a considerable resemblance to each other. Both have viscid, aromatic, rather soft leaves,* green on the upper surface and densely tomentose beneath. The tomentum—a very constant character in *Celmisia* species, and not sufficiently used for diagnostic purposes—*is identical in both plants.* It is smooth, very dense, closely adpressed to the leaf-surface, white and shining, and when magnified by 6 is seen to consist of fine cobwebby hairs. The midrib in both plants is prominent and large, especially towards its base, and pale-green in colour.† Some of the leaves are obscurely serrated. The leaves clasp the stem with a broad sheathing base which is stained purple on its lower half. The shoot-axes measure about the same in diameter in both specimens, 1·5 cm.; and the living leaves occupy the apical end of the shoot for about the same distance, while below are the withered leaves still attached to the stem.

There are, however, some differences, but these are merely of degree, and such as might be expected in any species from ordinary "fluctuating variation," and especially in New Zealand plants, when we bear in mind the extraordinary plasticity of so many species with regard to changes in their environment. But examination of more material would probably lead to somewhat different results.

The Bonpland plant has smaller and slightly differently shaped leaves to the Nuggets plant. The leaf-veins are a little more prominent on the under surface of the leaf and rather more sunken on its upper surface, giving a somewhat more wrinkled character to the surface. The leaves are also perhaps rather stiffer and a little darker green. On the other hand, the Nuggets specimen is decidedly the more aromatic of the two.

The following are measurements of the leaves of the two specimens:—

Nuggets.		Bonpland.	
Lamina.	Sheath.	Lamina.	Sheath.
cm. cm.	cm. cm.	cm. cm.	cm. cm.
11·7 by 2·2	2·6 by (?)	8·6 by 2·6	2·5 by 1·6
11·1 by 2·5	2·7 by 1·8	8·55 by 2·5	2·5 by (?)
11·4 by 2·5	2·6 by 1·6	8·3 by 2·6	2·45 by 1·7
11·2 by 2·55	2·8 by 2·55	9·9 by 2·8	2·4 by 1·7

* Kirk describes the leaves as "coriaceous, but not thick"; but that description applies only to dried specimens.

† In the Handbook it is described as black, a character evidently taken from a dried specimen.

From the above it may be seen that the Nuggets plant has leaves longer considerably but narrower in proportion to the Bonpland plant, which consequently gives them a different shape.

An examination of the literature on the subject, of plants in my herbarium, and of notes which I took personally some years ago at Nugget Point, shows that the Nuggets plants vary considerably in dimensions of leaf. For instance, my notes taken on the 3rd October, 1902, give, as an average size of certain leaves measured, 10·5 cm. by 1·9 cm., and a specimen collected by me in the same locality some months later gives the following: 9·7 cm. by 2·3 cm.; 10 cm. by 2·2 cm.; 8·4 cm. by 1·9 cm.; 9·8 cm. by 2·3 cm.; 7·5 cm. by 1·7 cm.; 7·2 cm. by 1·8 cm. A Catlin's River specimen collected by D. Petrie measures 14·6 cm. by 2·5 cm.; 11·2 cm. by 2·4 cm.; 14·5 cm. by 2·3 cm. A cultivated specimen sent me by T. Kirk of the Nuggets plant measures 13·6 cm. by 1·7 cm.; 13·2 cm. by 1·9 cm; 12·9 cm. by 1·9 cm. Hooker gives the dimensions of Lindsay's specimens as 6·4 cm. by 1·25 cm., and the plate in Lindsay's paper* shows a comparatively small plant. But these figures on the whole confirm the statement above, that the coastal plant has longer but narrower leaves in proportion to their length than the Bonpland plant.

In my herbarium is also a flowering specimen of the alpine plant collected in Matthews's garden by Petrie. This, so far as the flower goes, exactly matches Nuggets specimens. Its leaves measure 9·3 cm. by 2·1 cm.; 9·8 cm. by 2·35 cm. The scape of the alpine plant is of the characteristic flexuous form, which Hooker called attention to as a peculiar characteristic of *C. lindsayi*. Petrie (*l.c.*, p. 558) remarks that the Lake Harris specimens of Matthews "have a more robust habit than the sea-coast form."

In order to further test the differences between the two plants, I cut a number of transverse sections of the leaves. These, though agreeing in the main as to palisade, spongy parenchyma, &c., show one difference—viz, that the Bonpland plant has invariably a two-layered epidermis, while the Nuggets plant has one of one layer only, though the latter is occasionally two-layered for a short distance. Thus, this anatomical distinction, again, is one rather of degree than of actual difference.

Such are the facts of the case with regard to the alpine and coastal plants. There is undoubtedly a *Celmisia* on the Humboldt Mountains, common also in many places, although Kirk, Petrie, and myself, who have all been in the vicinity of its habitat, have never collected it. Moreover, this alpine Bonpland form

* "Contributions to New Zealand Botany," 1868.

differs from the coastal Nuggets form in some minor details, but only in such as might be expected from ordinary fluctuating variability, so that the two plants according to recognised floristic rules must be considered identical.

But are such floristic methods sufficient in this case? Mr. Matthews thus writes, and shows very clearly the position he takes with regard to the coastal and alpine forms: "In regard to *Celmisia lindsayi* and the Bonpland plant (sent yesterday), there is perhaps no clear actual botanical distinction, but when seen growing side by side they are dissimilar in many respects that could not be reduced to writing." This statement of Matthews opens up a very wide and most important question, but here a few general remarks must suffice. Professor L. H. Baile thus writes: "Many of us feel that the present methods of nomenclature and description will be outgrown, for these methods are made for the herbarium and museum rather than for the field. It is a most suggestive commentary that the botanist may know the species when it is glued on an herbarium sheet, but may not know it when it is growing. The nurseryman or gardener may know it when growing, but not when it is in an herbarium. This is not merely because the botanist is unfamiliar with the field or the gardener with the herbarium. These men have a different fundamental conception of what a species is; they use different 'marks'—one morphological, the other largely physiological. I believe that the gardener is nearer the truth."* The fact is, such cases as the one under consideration, and dozens of others much more striking which could be selected from the New Zealand flora, cannot be settled by a mere morphological examination. The truth does not rest on the dictum or perhaps whim of one man, or indeed of a number of men, but upon the observation of a simple fact—the power of the particular form in question to reproduce itself "true," or the contrary, from seed. If the progeny resembles the parent in those characters which distinguish this latter from all its allies, then we have to do with a distinct entity—an elementary species, as De Vries† has termed it—and such must receive a name; such elementary species are realities, whereas collective Linnæan species are merely ideas. The final court of appeal as to "specific value" is no longer the herbarium or study of the systematist, but the seed-bed of the experimental garden.

* "The Mutation Theory of Organic Evolution": Six addresses given before the American Society of Naturalists at Philadelphia, 28th December, 1903. "Systematic Work and Evolution," L. H. Bailey (Repr. Science, n. s., vol. xxi, No. 536, 7th April, 1904, p. 12).

† H. de Vries, "Die Mutationstheorie," band i, chapter v, § 21, "Species, Subspecies, and Varieties," pp. 115–20.

Art. XLV.—*Notes on a Brief Botanical Visit to the Poor Knights Islands.*

By L. Cockayne, Ph.D., Cor.F.B.S.Ed.

[*Read before the Philosophical Institute of Canterbury, 5th July,* 1905.]

1. General Remarks.

During a recent excursion in the Government steamer "Hinemoa" I had the good fortune, thanks to special facilities afforded by Captain J. Bollons, of botanizing on the Poor Knights Islands, a group which no naturalist had previously visited. Nor is this at all remarkable, for these islands lie out of the track of vessels, while it is only under the most exceptional circumstances that a landing can be effected.

The Poor Knights, or "Tawhiti Rahi," as the Maoris call them, lie isolated in the open ocean at about latitude 35° 30′ S., and distant some eleven miles from the east coast of northern Auckland. They consist of two precipitous islands lying in close proximity, and extending in a north and south direction for two miles and a half. They are of volcanic origin, and about 182 meters in height. As seen from the east the southern island is somewhat conical in form, but with a very broad base, while the northern island, although rugged enough, is much flatter in its upper part. Three miles to the south are the islets known as the High Peak Rocks, which rise to a height of 60 meters, and these must be included in the group.

Unfortunately the time at the captain's disposal was limited, so he was only able to allow me some two hours and a half for my work, a considerable portion of which was occupied by sailing round much of the two main islands in search of a landing-place. This, however, gave an opportunity of noting the distribution of certain conspicuous plant-formations.

We landed at two places on the southern island, one below the precipices on its west coast, not far from the very narrow strait which divides the two islands; and the other, where some rocks stretch out into the sea on the north-east side. This latter is the most favourable place from whence to explore the island, since a comparatively gentle slope up a wide, shallow gully, full of scrub or low forest, leads right to the summit of the island. Elsewhere, so far as I could judge, the coast is extremely precipitous.

I did not land on the northern island, but Captain Bollons and some of the sailors climbed up to the meadow above the cliffs on the west side, near the remarkable tunnel which there forms a narrow passage right through the island.

From the above it may be gathered that what follows regarding the vegetation is quite fragmentary—so much so, indeed, that but for the fact that nothing whatever was known abou the natural history of the Poor Knights I should not have ventured to publish these notes.

2. The Plant Formations.

Everywhere on the Poor Knights, excepting in the most unfavourable positions, such as faces of precipices, is an abundant vegetation. This, so far as I could judge, consists of three principal formations—viz., cliff, tall scrub, and meadow. There is also a limited amount of flat ground, more or less wet, near the rocks where we landed on the north-east of the southern island, where grow certain halophytes. This is treated below under the heading " Salt Meadow."

(*a.*) *The Cliff Formation.*

The cliffs vary considerably in their slope, and on this the richness or otherwise of their plant-covering chiefly depends. Where quite perpendicular, as in many places on the east of the northern island, plants—lichens excepted—are absent; but where the slope is more gentle there is frequently so abundant a covering that the rocks are clothed with greenery. The chief members noted of this formation were: *Poa anceps, Arundo conspicua* (*Gramineæ*); *Arthropodium cirrhatum, Phormium tenax* (*Liliaceæ*); *Rhagodia nutans, Salicornia australis* (*Chenopodiaceæ*); *Mesembrianthemum australe* (*Aizoaceæ*); *Apium prostratum* (*Umbelliferæ*); *Coprosma baueri* (*Rubiaceæ*); *Lobelia anceps* (*Campanulaceæ*); *Metrosideros tomentosa* (*Myrtaceæ*); *Polypodium serpens, Asplenium flaccidum* var. (*Filices*). Of these some play a much more important part than others. For instance, in some places the succulent *Mesembrianthemum* forms a close covering of bright-green; in others, colonies of the thick-leaved *Arthropodium** cover some square meters of the rock-surface, while near by the tall yellow plumes of *Arundo* wave in the breeze. *Poa anceps*, so common as a coastal grass in the north of New Zealand, in many places hangs in long tufts down the rock-face; and *Phormium tenax*, its large clumps of sword-like leaves a meter or more in length, stands out conspicuous from the cliffs.

* To show how this plant can resist drought, a plant which I collected on the Poor Knights on the 28th February, and had kept between drying-papers, was still alive and vigorous on the 14th April, at which date I planted it in my garden, where it grew vigorously, and by the 1st June has produced several roots more than 16 cm. in length.

(*b.*) *The Tall Scrub Formation.*

Even at a distance it can plainly be seen that much of the surface of both islands is occupied by a thick growth of low trees. A closer view shows that some of these stand out distinctly above the others. This at first led me to think that the former might be the rare *Meryta sinclairii*, which has for a long time been reputed as occurring on the Poor Knights.* But, as shown further on, these plants are merely *Cordyline australis*, so that the presence of *Meryta* on these islands still remains a moot point.

The formation under consideration occupies the gullies, together with that flatter ground forming the surface of the islands above the precipices. It seems to be of greatest extent on the southern island, where alone I had an opportunity of penetrating into it. Had the time not been so short it would have been quite easy to have gone right through the scrub to the summit of the island, but as it was I was only able to examine the part at no great distance from the sea.

Unlike the cliff formation, which is identical with that of the neighbouring mainland, the scrub is quite distinct from any allied formation with which I am acquainted in the New Zealand biological region, not because it contains any peculiar or rare species, but from the special combination of its members.

Seen from without, the scrub presents a dense mass of foliage, greyish or green in colour. Between the scrub proper and the open ground bordering on the sea is a broad, thick belt of *Phormium tenax*, while in places within this again is a good deal of low-growing *Metrosideros tomentosa*, the representative here of the characteristic belt of that tree along most of the rocky shores in northern New Zealand. Here, too, outside the scrub, is *Myoporum lætum*—not an erect tree as usual, but semi-prostrate. This unusual habit did not surprise me, for on the Moko Hinou Islands and on Cuvier I had already observed numerous absolutely prostrate plants, looking on this account altogether different from the normal tree. How far this prostrate habit is hereditary and the plant an elementary species, or whether it is merely a case of fluctuating variation, the result of constant winds on plants which would otherwise be upright, has yet to be ascertained—an easy enough matter to determine by means of culture experiments.

The two dominant plants of the scrub are *Suttonia divaricata* (*Myrsinaceæ*) and *Macropiper excelsum* (*Piperaceæ*). *Melicytus ramiflorus* (*Violaceæ*) appears to come next in abundance.

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* See T. Kirk, "An Account of the Puka (*Meryta sinclairii*, Seem.)," Trans. N.Z. Inst., vol. ii, p. 100, 1870.

Associated with these, but in much smaller proportion, are *Hymenanthera latifolia* (*Violaceæ*), *Myoporum lætum* (*Myaporaceæ*), *Entelea arborescens* (*Tiliaceæ*), *Geniostoma ligustrifolia* (*Loganiaceæ*), *Corynocarpus lævigata* (*Anarcardiaceæ*), and *Sideroxylon costatum* (*Sapotaceæ*).

The scrub is about 3 m. tall. The low trees or tall shrubs—call them as you please—have usually rather slender naked trunks and dense heads of foliage. The ground is bare for the most part, but here and there are seedlings of the different species, together with *Veronica macroura** and a few ferns. It was pleasant to note that the bell-bird (*Anthornis melanura*), now all but extinct in many places, was plentiful. Further from the sea the scrub probably changes its character considerably, for *Cordyline australis* (*Liliaceæ*) becomes one of the most abundant members, its much-branched heads raised above the other foliage and rendered conspicuous at a distance through this and their yellowish-green colour.

With the exception of *Suttonia divaricata*, the presence of which was most unexpected, and which separates this scrub most distinctly from any other formation, its other members are what might be expected in a northern coastal forest. But *S. divaricata* is by no means a common plant in the north of New Zealand, so Mr. T. F. Cheeseman informs me. It, however, is much commoner as we go further south, until on the Auckland and Campbell Islands it becomes one of the characteristic forest or scrub plants.† From Mr. R. H. Matthews, of Kaitaia, to whom I wish to express my obligation for botanical assistance, I learn, however, of a still more anomalous station for this shrub—viz., on mangrove islands in the Rangaumu Estuary.

The most striking ecological fact about this scrub of the Poor Knights is that, notwithstanding the small size and consequent exposure to fierce winds of the islands, the foliage of many of the plants is abnormally luxuriant. *Macropiper excelsum* is probably that large-leaved variety originally discovered by Cheeseman on the Kermadec‡ and Three Kings Islands.§ The leaf-blades of my specimens measure ± 16 cm. by $\pm 16\cdot 6$ cm.

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* If the identification be accurate this extends the range of this plant considerably to the northward, at the same time affording evidence that the Whangarei habitat of Colenso is correct.

† Cockayne, L., "A Botanical Excursion during Midwinter to the Southern Islands of New Zealand" (Trans. N.Z. Inst., vol. xxxvi, 1904, p. 251).

‡ "On the Flora of the Kermadec Islands" (Trans. N.Z. Inst., vol. xx, 1888, p. 154).

§ "Notes on the Three Kings Islands" (Trans. N.Z. Inst., vol. xxiii, 1891, p. 412; see also p. 415 as to the large-leaved *Geniostoma*).

Those of *Myoporum lætum* measure ± 14·5 cm. by ± 6·2 cm., whereas Kirk gives from 2·5 cm. to 10 cm. long by 1·3 cm. to 3·8 cm. broad.* The leaves of the *Melicytus* and *Geniostoma*, too, are considerably above the average. But most surprising of all are the leaves of *Suttonia divaricata*. These on specimens from the Southern Islands measure 11 mm. by 10 mm.,† but those of Poor Knights plants are 33 mm. by 22 mm.; moreover, they are thin, and not "somewhat coriaceous."

Such luxuriance of foliage on wind-swept small islands, far out in the open ocean, where the contrary might be expected, is not easy of explanation. There is far more shelter than might be thought at first glance, for usually the formation will only get the wind from one quarter, while the dense growth of the whole also protects the individual members. The air, too—although no statistics are available—may be assumed to be always highly charged with moisture, and so will check transpiration and encourage leaf-development. Finally, the volcanic soil of the islands is probably extremely fertile. Mr. T. Kirk long ago called attention to a similar condition of affairs on the lava-field of Rangitoto, the well-known landmark in the Hauraki Gulf, the richness of whose vegetation in conjunction with the apparent absence of soil and water must strike even the most careless observer. My above explanation, so far as it goes, adds little to that originally put forth by Kirk.‡ I must confess, however, that it seems to me at best but a partial solution of this puzzling question.

(*c*.) *Meadow.*

Regarding this formation I can say little, having only seen it from a distance. Captain Bollons, however, as mentioned above, climbed up to the open gound above the cliffs of the northern island, bringing back for me a few specimens of the meadow vegetation. The ground is in many places carpeted with *Mesembrianthemum australe*. Everywhere is *Phormium tenax*, sometimes in large masses, at other times dotted about. Large tussocks of *Arundo conspicua* here and there all over the meadow give a distinct character to its physiognomy. Roundish bushes, too, of stunted *Metrosideros tomentosa* are frequent. The meadow is broken into in many places by greater or smaller pieces of scrub, thanks to the shelter afforded by the *Phormium*. Whether this scrub is similar to that described above I am not in a position to say. Neither can I bring for-

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* "Forest Flora," p. 253.

† *Loc. cit.*, p. 251.

‡ "Notes on the Botany of Waiheke, Rangitoto, and other Islands in the Hauraki Gulf" (Trans. N.Z. Inst., vol. xi, 1879, pp. 451, 452).

ward any facts as to the causes determining the presence of meadow or scrub, though doubtless it is largely a matter of degree of exposure to the prevailing winds. Captain Bollons made one most interesting discovery. At the base of the *Phormium* plants he observed large numbers of the great snail *Placostylus hongii*, var. *novoseelandica*, now quite extinct on the mainland, but still occasionally to be found on the small island, Cape Maria van Diemen.

(*d.*) *The Salt Meadow.*

Here the presence of that collection of halophytes to which I am giving the name "salt meadow" for comparative purposes is dependent rather on the sea-spray blown inland, and on the lack of shelter, than on any other factors. The ground is more or less wet, in some places water lying on the surface. Here the vegetation is richest, the dominant plant being the rush-like and strongly xerophytic *Leptocarpus simplex* (*Restiaceæ*). Other plants of this formation are: *Lobelia anceps* (*Campanulaceæ*), *Juncus maritimus*, var. *australiensis*, and *J. planifolius* (*Junceæ*), *Paspalum distichum* and *Deyeuxia billardieri* (*Gramineæ*), *Mariscus ustulatus* (*Cyperaceæ*), *Apium prostratum* (*Umbelliferæ*), *Samolus repens*, var. *stricta* (*Primulaceæ*), and *Carmichælia williamsii* (*Leguminosæ*). If my identification of this latter plant be correct—and both Messrs. Petrie and Cheeseman, to whom I have shown specimens, are of opinion that it is so—its presence on the Poor Knights is very remarkable.* Between the "salt meadow" and the scrub is the zone of *Phormium* before mentioned, which may perhaps be included in this formation.

Regarding the occurrence of *Carmichælia williamsii* a few words may not be out of place. Up to the present this most striking plant† of a remarkable genus has only been recorded from the East Cape district, where it is rare and local. The only explanation that I can suggest as to its occurrence in two places so far apart is that it was once much more widely distributed along the east coast of northern New Zealand, but shrinkage of the land-surface has led to a fiercer struggle for existence, which has caused its extinction except in a few specially situated localities. It is just on islands which once upon a time formed part of the mainland, or in peculiar stations such as the cliffs of the East Cape, that relics of a former vegetation might be expected. The North Cape, at no very distant date

* Mr. Cheeseman has also, since writing the above, very kindly given me an opportunity of examining a type specimen of *C. australis*, var. *lata*, from the herbarium of the late Mr. T. Kirk, which certainly is quite distinct from the Poor Knights plant.

† See fig. 3, pl. xxvi, Featon, E. H., "The Art Album of the New Zealand Flora."

an island, is a case in point. Here Cheeseman* discovered four plants not found elsewhere, which may well be considered either remnants of a more extensive ancient coastal flora, or new species which originated during a separation of the place in question from the mainland. But in the case of *Carmichælia williamsii* the former supposition seems the more feasible. This view is also supported by the occurrence of *Veronica macroura* on the Poor Knights, another species known authentically only from the East Cape region and the coast for some distance to the south, including Portland Island.

3. Summary of Results.

1. There are three principal plant formations on the Poor Knights—viz., cliff, tall scrub, and meadow—and a minor formation composed principally of halophytes.

2. The cliff formation is identical with that of the adjacent coast.

3. The scrub, owing to the combination of its members and the presence of *Suttonia divaricata* as a dominant species, differs from any allied formation in the New Zealand biological region.

4. *Carmichælia williamsii*, a plant hitherto only known from the East Cape district, much further to the south, occurs on the Poor Knights, and its limited distribution in New Zealand may be explained on the supposition of a shrinkage of the land-surface, with a consequent increase in the struggle for existence and the extinction of plants over wide areas, leaving the survivors isolated in such places as small islands.

5. The arborescent plants exhibit a most remarkable luxuriance of foliage, greater considerably than that of the same species on the mainland.

Before concluding I must express my sincere thanks to the Hon. W. Hall-Jones, Minister of Marine, for his kind assistance in furthering my botanical work on this and previous occasions.

4. List of Plants collected or observed on the Poor Knights.

Filices.

Asplenium flaccidum, *Forst.*, *var.*
Polypodium serpens, *Forst.*
Pteris esculenta, *Forst.*
,, tremula, Br.

* "On the Flora of the North Cape District" (Trans. N.Z. Inst., vol. xxix, 1897, p. 363).

Gramineæ.

Arundo conspicua, *Forst. f.*
Deyeuxia billardieri, *Kunth.*
Dichelachne crinita, *Hook. f.*
Oplismenus undulatifolius, *Beauv.*
Paspalum distichum, *L.*
Poa anceps, *Forst. f.*

Cyperaceæ.

Carex dissita, *Sol.*
Mariscus ustulatus, *C. B. Clarke.*
Scirpus nodosus, *Rottb.*
,, prolifer, *Rottb.*
,, cernuus, *Vahl.*

Restionaceæ.

Leptocarpus simplex, *A. Rich.*

Juncaceæ.

Luzula, *sp.*
Juncus maritimus, *var.* australiensis, *Bucnen. Laır.*
,, planifolius, *R. Br.*

Liliaceæ.

Arthropodium cirrhatum, *R. Br.*
Cordyline australis, *Hook. f.*
Phormium tenax, *Forst.*

Piperaceæ.

Macropiper excelsum, *Miq.*
Parietaria debilis, *Forst. f.*

Polygonaceæ.

Muehlenbeckia complexa, *Meissn.*

Chenopodiaceæ.

Rhagodia nutans, *R. Br.*
Salicornia australis, *Sol.*

Aizoaceæ.

Mesembrianthemum australe, *Sol.*

Caryophyllaceæ.

Tissa media, *L. f.*

Ranunculaceæ.

Clematis parviflora, *A. Cunn.*

Cruciferæ.

Lepidium oleraceum. *Forst. f.*

Pittosporaceæ.

Pittosporum crassifolium, *Sol.*

Leguminosæ.

Carmichælia australis, *R. Br.*
,, williamsii, *T. Kirk.*

Oxalidaceæ.

Oxalis corniculata, *L.*

Linaceæ.

Linum monogynum, *Forst. f.*

Anarcardiaceæ.

Corynocarpus lævigata, *Forst.*

Tiliaceæ.

Entelea arborescens, *R. Br.*

Violaceæ.

Hymenanthera latifolia, *Endl.*
Melicytus ramiflorus, *Forst.*

Thymeliaceæ.

Pimelea lævigata, *Gaert., var.*

Myrtaceæ.

Metrosideros tomentosa, *A. Rich.*

Haloragidaceæ.

Haloragis erecta (*Murr.*), *Schindler.*

Umbelliferæ.

Apium prostratum, Labill.

Epacridaceæ.

Leucopogon fascicularis, *A. Rich.*

Myrsinaceæ.

Suttonia divaricata, *Hook. f.*

Primulaceæ.

Samolus repens, *Pers.*, *var.* stricta, *Cockayne.*

Sapotaceæ.

Sideroxylon costatum, *F. v. Muell.*

Loganiaceæ.

Geniostoma ligustrifolia, *A. Cunn.*

Solanaceæ.

Solanum aviculare, *Forst. f.*
,, nigrum, *L.*

Scrophulariaceæ.

Veronica macroura, *Hook. f.*

Myoporaceæ.

Myoporum lætum, *Forst. f.*

Rubiaceæ.

Coprosma baueri, *Endl.*
,, robusta, *Raoul.*

Cucurbitaceæ.

Sicyos australis, *Endl.*

Campanulaceæ.

Lobelia anceps, *L. f.*
Dichondra repens, *Forst.*

Compositæ.

Gnaphalium luteo-album, *L.*
Sonchus oleraceus, *L.*
Erigeron canadense (*introduced*).

Art. XLVI.—*Notes on the Subalpine Scrub of Mount Fyffe (Seaward Kaikouras).*

By L. Cockayne, Ph.D., Cor.F.B.S.Ed.

[*Read before the Philosophical Institute of Canterbury, 12th December,* 1905.]

1. Introduction.

The Seaward Kaikouras, or Looker-on Mountains, are a lofty range running at first almost parallel to the coast of eastern Marlborough, but finally striking further inland. They commence near the mouth of the River Clarence and end at the source of the Conway, whence under other names the chain is continued until it joins the Southern Alps. The highest peaks are Mount Whakari, 2,591 m., and Mount Kaitarau, 2,652 m., but the range as a whole maintains a high altitude. It consists for the most part of dark-coloured shales and of sandstones. The former are very crumbly, and give rise to vast shingle-slips of sombre and forbidding aspect. Mount Fyffe, 1,624 m. in height, is one of the lower peaks, and perhaps the most easy of access. It abuts directly upon the Kaikoura Plain, of which it forms the north-western boundary. The torrential rivers, Kowhai and Hapuka, separate Mount Fyffe from the main range, to which it is joined merely by a narrow saddle.

Regarding the flora of the Seaward Kaikouras little has been published. From their great height, and position with regard to the eastern seaboard of the South Island and to the Inland Kaikouras, from which they are altogether separated by the Clarence Valley, it might be expected that they would possess some plants of special interest. And this was known to be the case even so early as the publication of the "Flora Novæ-Zelandiæ," for in that work the wonderful shrub *Helichrysum* (*Ozothamnus*) *coralloides* is mentioned. Kirk, in the "Students' Flora," also cites some interesting plants which he had himself discovered—namely, the *Ranunculus, Olearia,* and *Cassinia*—which are treated of at some length below. In February, 1902, I collected on Mount Fyffe a rather remarkable *Celmisia,* which may be an undescribed species, but which in the "Students' Flora" is referred to *Cel. sinclairii* as "a form with serrated very coriaceous oblong bracts" (p. 285). On the same occasion I also collected an *Epilobium,* which is referred to below. In 1869 Buchanan published a short paper of six pages only dealing with the botany of the Province of Marlborough as a whole.* This contains a very brief account of the distribution of plants on a western spur of Mount Kaitarau. The increase of our knowledge as to species of New Zealand plants since that date shows that in certain instances wrong identifications were made, as is evidently the case with regard to *Ranunculus pinguis, Veronica hectori,* and *Myosotis capitata.* Buchanan also came to the curious conclusion that few additions would be made to his list of the alpine plants, since he writes, "There is little doubt that the shepherds employed to search for plants there [*i.e.*, on the Kaikoura Mountains] have pretty well exhausted them." Mr. R. Brown has collected mosses in the valley of the Hapuka, and has described some of the novelties he discovered in the "Transactions of the New Zealand Institute."†

My own acquaintance with the Kaikouras commenced in 1902, when in the February of that year I partially ascended Mount Fyffe twice, and once crossed over its summit, following the long spur from the River Kowhai and descending by another spur leading directly from the summit to the plain near the north end of the mountain. A year or two later Mr. Brown and myself camped for some days near the River Conway, which we followed up to its source and to the Palmer Saddle. Quite recently (October, 1905), in company with Mr. and Mrs. H. J. Matthews, I had the great pleasure of again visiting Mount Fyffe and ascending as before by the Kowhai Spur to a height of about 1,067 m. During the thirteen years that have elapsed since my first visit my knowledge of New Zealand plant formations has been considerably extended, so that the subalpine scrub at once struck me as being different from any that I had observed elsewhere. Mr. Matthews, whose knowledge of living New Zealand plants and of their stations is very wide, also agreed that the formation in question was quite distinct from any he had seen before. Therefore it seems well to put on record some details concerning it, such publication being the more desirable since at any time the scrub may be in large measure destroyed by fire. If this were the case, it must also be borne in mind that the formation could never reappear in its primeval form.‡

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* Journ. Linn. Soc., Botany, vol. x, 1869, p. 63.

† "On the *Musci* of the Calcareous Districts of New Zealand, with Descriptions of New Species" (Trans. N.Z. Inst., vol. xxxv, 1903, p. 323).

‡ Cockayne, L., "On the Burning and Reproduction of Subalpine Scrub and its Associated Plants" (Trans. N.Z. Inst., vol. xxxi, pp. 416–17, 1899)

2. General Remarks on the Subalpine Scrub of New Zealand.

Before proceeding with the details of the subalpine scrub of Mount Fyffe, some general remarks on this plant formation and its allied formations in New Zealand as a whole do not seem out of place.

To the various associations of shrubs which are so frequently met with at all altitudes from sea-level to the subalpine region the New Zealand colonists give the name "scrub." And no word can better express the character of such assemblages, the members of which are of an extremely dense habit of growth, with stiff or wiry interlacing or divaricating branches, seemingly bearing the impress of countless furious gales. Such scrubs are usually related, both ecologically and floristically.

Characteristic stations are the sea-coast between forest and sea-shore (coastal scrub), river terraces in the montane region, and fans of rivers issuing from mountain torrents (terrace scrub and in some cases river-bed scrub), stony beds of glacier rivers near their source, moraines, and the upper margin of the subalpine forest, where the scrub forms a compact and dense belt between the forest and the subalpine meadow. It is to the three last categories that the term "subalpine scrub"* is here applied. Such a formation is not to be encountered on all New Zealand mountains. It is found in greatest perfection on those where the rainfall is excessive and the rainy days numerous, while where the driest conditions prevail it may be wholly wanting, or restricted to a few sheltered spots such as gullies or moist hollows.

Ecologically the subalpine scrub consists of shrubs or low trees, with one exception evergreen, and usually of a xerophytic character. Amongst the more common adaptations of these shrubs are the following: (*a*) Dense habit of growth, with much-interlacing branches and small leaves; (*b*) coriaceous hard and stiff leaves, very frequently clothed with tomentum on their under surface; (*c*) vertical needle-shaped leaves at the extremities of stiff, erect, naked branches; (*d*) leaves

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* In the English translation of Schimper's "Plant Geography," p. 761. this formation is termed "elfin-wood and shrub," a by-no-means happy rendering of the German *Krummholtz und Gestrauch*. It seems to me that the term "subalpine scrub" is much more expressive. As for the *Krummholtz*, it is represented in New Zealand chiefly by the stunted trees which sometimes form the upper zone of a subalpine forest, and of which *Nothofagus cliffortioides*, only a meter or so in height, is an excellent example. Such, if they occur in company with other shrubs, I should include in the subalpine scrub. Diels also translated *Knieholtz* as "subalpine scrub" ("Vegetations-Biologie von Neu-Seeland," p. 261).

reduced to scale-like organs closely pressed against the shoot-axis; (*e*) recurving of leaf-margin. Many of the plants, too, have aromatic leaves, and a number are hygrophytic in the juvenile and xerophytic in the adult form.

Floristically, the formation under consideration contains a diverse assemblage of genera and orders made up of shrubby veronicas, composites, epacrids, taxads, araliads, and rubiaceous plants, together with certain other shrubs such as *Pittosporum rigidum*,* *Aristotelia fruticosa*, *Suttonia divaricata*, and *Gaya lyallii*. Herbaceous subalpine and alpine plants grow under the shelter of the shrubs, where these latter are not too dense, while *Phormium cookianum* and the giant umbellifer, *Aciphylla colensoi conspicua*, when present, easily hold their own with the arborescent vegetation.

Such a belt of shrubs may vary much in breadth and height, but it is always most difficult to penetrate, and in some places is all but impassable, unless a track be cut through it. As for the composition of its members, this is far from uniform for all New Zealand mountains. Various plants are dominant in different regions, or even in adjacent scrubs. Thus, at the source of the River Poulter in the Snowcup Mountains the physiognomy of the adjacent scrubs is so entirely different that it is easy to tell at a distance whether *Gaya lyallii*, *Dracophyllum traversii*, or *Phyllocladus alpinus* are dominant. Also, the arrangement, number, and proportion of the constituents vary in different localities. As for the shrubs themselves, some belong exclusively to the subalpine region,† such as *Nothopanax lineare*, *Olearia lacunosa*, *O. illicifolia mollis*, *O. excorticata*, *Veronica hectori*, *V. subalpina*, *Senecio bidwillii*, *Dracophyllum traversii*; others again, such as *Olearia illicifolia*, *Coprosma propinqua*, *Cassinia vauvilliersii*, *Dracophyllum longifolium*, and *Nothopanax colensoi*, are common to all levels from the subalpine to the sea; while, finally, some others are especially plants of "terrace scrub," such as a number of veronicas, including *V. cupressoides*.

Notwithstanding the special climatic and edaphic conditions which govern the distribution of the subalpine-scrub vegetation,

* Quite recently on the Tararua Mountains I saw the typical *P. rigidum*, Hook. f., growing in abundance. It seems to me quite distinct from the above plant, which is common in many parts of the South Island, but in this paper the usual identification may stand.

† Of course, it is not impossible to find stray plants of any region in one to which they do not properly belong. Thus I have observed the truly subalpine and perhaps alpine *Ranunculus lyallii* at sea-level, Milford Sound, and *Helichrysum grandiceps* at 400 m. in Westland; but that does not exclude these plants from being considered rightly as plants of a much higher altitude.

many of the shrubs are easy to cultivate, and have become favourite garden-plants in various parts of Europe, where they are more prized and better known than in New Zealand. Some of the finest are, however, still very rare or unknown in cultivation, as, *e.g.*, *Olearia lacunosa*, *O. excorticata*, *O. capillaris*, *O. illicifolia mollis*, *Cassinia albida*, and *Dracophyllum traversii;* but this latter magnificent small tree is not easy to cultivate or to propagate.

3. The Subalpine Scrub of Mount Fyffe

(*a*.) *General Features.*

At a height of about 940 m. the subalpine scrub is first encountered upon Mount Fyffe, forming, so far as I could observe, a narrow belt varying in width from perhaps 20 m. to 45 m. along the upper margin of the mixed forest which thickly clothes the lower parts of the mountain to its base. This scrub consists in very large measure of *Cassinia albida*, which in many places makes an almost pure formation, and which everywhere far and away exceeds the other plants in amount. Here and there mixed with the *Cassinia*, but always in small quantities, are the following: *Veronica traversii*, *Veron. leiophylla*, *Dracophyllum uniflorum*, *Aristotelia fruticosa*, *Aristot. colensoi*, *Podocarpus totara*, *Rubus australis*, *Gaya ribifolia*, *Olearia cymbifolia*, *O. coriacea*, *O. forsteri*, *Senecio geminatus*, *Coprosma parviflora*, *Cop. rhamnoides*, *Phormium cookianum*, and *Aciphylla colensoi*. Of the above some are very rare indeed, only two plants of *Olearia coriacea* and one of *O. forsteri* being observed.

Viewed from a short distance the formation appears a mass of sage-green, due to the superabundant *Cassinia*, with its small leaves green on the upper and white on the under surface, but relieved here and there by the dark-green upright sword-like leaves of the *Phormium*. As the eye becomes used to the monotone of the *Cassinia*, other greens, and even browns, become evident—*e.g.*, *Veronica traversii*, yellowish-green; young trees of totara, these a little taller than the rest of the scrub, and of somewhat the same hue as the *Veronica;* and *Dracophyllum*, its close erect needle-like leaves reddish-brown in the mass. *Gaya ribifolia* is also present in sufficient quantity to make its mark, but at the time of my visit it was leafless. At a later period its leaves of a tender-green, and its wealth of white cherry-like blossoms, must form a striking feature of the scrub.

On the fairly deep soil beneath the shelter of the shrubs are the following herbaceous plants and ferns: *Acæna sanguisorbæ*, var., forming a carpet over the ground in many places, with the short erect fronds of *Lomaria alpina* growing through it. Here and there, like a pigmy pine-tree, is *Lycopodium fastigiatum*. *Ligusticum aromaticum* and *Geranium microphyllum* are also common, but their lowly habit renders them inconspicuous. More striking, especially when in bloom, is a species of *Epilobium*, allied to *Ep. chloræfolium*, with rather large reddish leaves and very large white flowers. Here and there, scattered through the scrub, where the sheep cannot destroy them, are the large silvery leaves of *Celmisia coriacea*. But the feature of the undergrowth, and that which gives it its special character, is the splendid buttercup *Ranunculus lobularis*, with its large orbicular or subpeltate leaves and tall stems crowned with golden-yellow flowers.

The general height of the scrub is some 1·2 m. to 1·5 m., and the shrubs, themselves of a dense habit, grow closely together. This makes the formation not easy to penetrate, especially where *Rubus australis* has invaded it from the neighbouring forest and binds the shrubs closely together with the hooked prickles of its petioles and mid-ribs. All the same, this subalpine scrub cannot be put into the same category with regard to its impenetrability as that of a mountain in the western Southern Alps or Stewart Island, or especially such a scrub as occupies the hillsides and valleys of Campbell Island.

(*b*.) *Climate.*

Before considering the life-forms of the various members of the subalpine scrub, such details as are available with regard to the climatic conditions to which it is subject must be given. These are, however, very incomplete and quite lacking scientific accuracy. In fact, with one or two exceptions, no meteorological records have as yet been taken in the subalpine region of New Zealand, and none are available for the Kaikoura Mountains. Thanks, however, to the enthusiasm of Dr. John St. C. Gunn, F.R.Met.Soc., statistics are available for the past eight years as to the climate of the Kaikoura Plain at near sea-level. Moreover, Dr. Gunn has very kindly supplied me with some important details as to the climate of Mount Fyffe itself, which have a distinct bearing on the ecology of its plant-covering, regarding which he thus writes to me : "I am sending you the information you ask for. Of course, it can only be approximately correct, but I have discussed the matter with Mr. A. Kennedy, who owns the Mount Fyffe Run, and also with Mr. James Dunbar, the head shepherd at Greenhills, who from many years' experience of the ranges ought to know."

Taking the seven years from 1897 to 1903 inclusive, the mean yearly maximum temperature was 17° C., the mean yearly minimum −5·9° C., the absolute maximum 34·4° C., the absolute minimum − 6·1° C., and the mean daily range 11·4° C. Judging from the plants cultivated in gardens at Kaikoura, and which are never damaged by frost—*e.g.*, *Pelargonium* sps., and *Albizzia lophantha*, Benth.—the minimum temperature as given above seems too great, but Dr. Gunn informs me that the frosts are of very short duration indeed.

The average yearly rainfall for the above seven years was 90·8 cm., and the total number of rainy days ninety-nine. The largest fall of rain recorded was 16·87 cm. on the 18th October, 1900. Snow rarely falls, and then only lies for a few hours; but on rare occasions a heavy fall takes place and the ground is white for four or five days.

As for the temperature of Mount Fyffe itself no positive facts can be given. The atmosphere is at times very clear, and then the solar radiation must be considerably greater than on the plain. One has only to ascend the mountain on a perfectly cloudless day to become well aware of this. Allowing the fall in temperature to be 0·5° C. for each 100 m., then the temperature at the subalpine-scrub line would be 4·7° C. lower than at sea-level. But such data as this may be very wide of the mark. One thing seems fairly clear—namely, that on all the New Zealand mountains, generally speaking, the cold of winter is not nearly as severe as it is popularly supposed to be; for New Zealand subalpine plants—veronicas, for instance—are almost all not hardy in the neighbourhood of London, but are killed or cut to the ground if the frost be at all above the average.* The length of time that snow lies on a mountain, and the limit of the winter snow-line, is a matter of great moment with regard to the plant-covering—in fact, the winter snow-line is, in my opinion, the point of demarcation between the alpine and subalpine regions, while the average distance to which an average winter fall of snow reaches and remains for a day or two on the lower slopes marks the beginning of the subalpine region proper. The following is supplied by Dr. Gunn: The winter snow-line is, on Mount Fyffe, at a distance of 184 m. to 303 m. from the summit, and from this point to the top of the peak snow lies for six months during the year. An ordinary winter snowfall

* Numerous instances could be quoted from the English horticultural papers. The following must suffice. Dallimore, W., *Veronica traversii*, "Garden," vol. lxvi, p. 391, 1904: "About London it is impossible to grow *Veronica speciosa* out of doors the whole year round, and of the forty or fifty species in cultivation very few can be said to stand unharmed through a winter of moderate severity. At Kew *V. traversii* is found to stand the best, though in a severe winter it is damaged, but when a succession of mild winters is experienced it becomes very strong and sturdy, and grows into a bush 2½ ft. or 3 ft. in height and 3 ft. to 4 ft. through."

descends to about 909 m. altitude, and here it may lie for about a week. From this it can be seen that the subalpine scrub will never be exposed to the heavy weight of snow which will be borne by the alpine plants proper, and that it will have usually no protection from the numerous frosts of winter and from those others which may occur at any season of the year.

During five months of summer the whole of the Seaward Kaikoura Mountains are clear of snow, although occasionally at Christmas there remains a small patch on the south-west flank of Mount Kaitarau, close to its summit. Often, however, in December, November, and October there may be a fall of snow on the mountains which disappears in the course of a day or two.

As for the rainfall, Dr. Gunn points out that even at the base of the mountain it is greater than at Kaikoura, and higher on the slopes it must be much greater still. My experience of Mount Fyffe during my first visit gave me some idea as to the climate of that mountain. When the wind blew from the sea—a very common wind—the mountain rapidly became enveloped in mist, which turned into rain of greater or less violence. On one occasion, only a few drops of rain fell at the base of the mountain, but above, the fall was so heavy as to cause a creek, dry in the morning, to flood the road on either side of its course in the afternoon for a distance of more than 15 m. The day on which I climbed to the summit of Mount Fyffe was quite clear in the morning, but at noon a mist gathered on the summit, and in an incredibly short time the rain came down in torrents, and so continued during the whole descent.

(c.) *Floristic and Ecological Details regarding the Members of the Scrub.*

To come now to the life-forms of the plants. *Cassinia albida* is, so far as has been recorded hitherto, confined to the Kaikoura Mountains and their vicinity. It is especially distinguished from *C. vauvilliersii*, of which Kirk considered it a variety, in the tomentum of the under surface of the leaf, which is white or yellowish-white, and not fulvous as in this latter species, and this character gives the shrub a most distinct appearance. There are two forms of *C. albida*—the one with a thin covering of hairs on the upper surface of the leaf, which is not noticeable without close examination, and does not in the least veil the green of the leaf; the other covered with a mat of fine white hairs on the upper surface of the leaf, so as to give the whole plant the appearance of being covered with dust or afflicted with a mildew. This form, though not nearly so common as the type, is to be encountered everywhere, and probably comes true from seed. For it I propose the name "*canescens*," which would either be a variety of *C. albida*, if that be considered a species, or form *canescens* of *C. vauvilliersii.* Whatever view be taken matters little so long as so distinct a plant has a name. When growing amongst the scrub *Cassinia albida* is a shrub of slightly straggling habit, having many branches prostrate towards the base and then ascending, but quite naked except towards their apices. Here are given off from the main axis numerous close, short, erect shoots, ± 13 cm. in length, their lower halves unbranched and densely leafy, but above furnished with many short lateral shoots, given off from the stem at an acute angle, the length of the basal and largest shoots being ± 2·7 cm. Such shoots are also all densely leafy, and the whole erect dense head of foliage may be about 22 cm. long by 20 cm. broad. The leaves are closely imbricating in the bud, but when fully developed are patent, the lamina being bent at right angles to the short petiole. In size they measure about 1·1 cm. to 1·4 cm. in length by about 4 mm. in breadth, which is larger than the measurements given by Kirk and Hooker for *C. vauvilliersii.* The var. *canescens*, at least in my specimens, has rather longer leaves still—1·6 cm. The margins are sometimes faintly recurved. On the under surface of the leaf is a dense tomentum of matted, fine hairs. The shoot-axes are also densely tomentose. The young leaves are extremely glutinous, and give off a somewhat aromatic odour, which is quite evident as one passes through the scrub.

Cassinia albida is not only found in the subalpine scrub, but descends to the river-flats on the Kaikoura Plain, where it would probably be more common but for the close growth of *Leptospermum scoparium*, with which in that situation it can ill compete. This is also shown on the mountain, where if a portion of the forest or scrub be burnt a *Leptospermum* heath takes possession, and becomes so strong a feature of the landscape that one might easily take it for a primitive formation. *C. albida* grows readily from seed, and in some parts of Mount Fyffe the montane meadow contains colonies of this plant. In such places are other forms of *Cassinia*—referrable perhaps to *C. fulvida* or to *C. vauvilliersii*—which form a bewildering mixture; or it may be that *C. vauvilliersii* is in a state of mutation, and that new forms are coming into being at the present time.

Olearia coriacea, of which only two adult and one juvenile specimen were noted, is a plant of considerable interest. During my former visit to Mount Fyffe I had not noticed it, but Kirk had found it there and also in the Awatere district. Notwithstanding that he had no flowering specimens, he described it in the

"Students' Flora," p. 276, as he considered it to be a distinct species quite unlike any other. *Olearia coriacea* is a rather tall shrub, having few rigid rather tortuous branches. Below these branches are naked, but above they branch into short densely leafy twigs. Such leafy part is ± 18 cm. long. The leaves are small, extremely coriaceous, shortly petiolate, and covered on their under surface with a very dense tomentum, white with a faint brownish tinge. The upper surface is yellowish-green, strongly marked by the reticulating veins, which give rise on the under surface to distinct lacunæ. The most striking feature about the leaf is its curious curving, the margins being so recurved and the leaf so arching upwards as to resemble a saddle, the apical portions being so recurved as to almost meet, while this part of the leaf curves upwards, ending in a point and thus forming the front of the saddle, the leaf-base being broad and rounded, and the centre forming the hollow. There were no signs of the young inflorescence, but the remains of those of last year showed that it is a short panicle about 3·5 cm. long. In shape, when flattened out, the leaves are ovate or broadly ovate, and the blade measures from about 2·1 cm. by 1·3 cm. to about 1·4 cm. by 8 mm. Growing near by was a plant of *Olearia forsteri* with small leaves, and one plant of a form of *O. cymbifolia* with large leaves, and this suggested both to Mr. Matthews and myself that perhaps the plant under discussion may be a hybrid between these two latter species.

Phormium cookianum, which comes next in abundance to the dominant *Cassinia*, is a frequent important constituent of subalpine scrubs. Its powers of resisting drought are very great, since it often grows also on faces of rock in close vicinity to the sea.

The two *Coprosmas* and *Aristotelia fruticosa* are common members of subalpine and river-terrace scrub, having the wind-shorn habit of so many New Zealand shrubs. The branches are interlacing, and the leaves small. The plants noted of the *Aristotelia* were not of the extreme xerophytic type that the species frequently assumes, showing in no case the reduction of leaves and the semi-spinous shoots that I have recorded elsewhere.*

Dracophyllum uniflorum, like some others of its congeners, has erect needle-like leaves, an obvious xerophytic adaptation. *Gaya ribifolia* is the plant of the drier mountains. It is rather more hairy than its close relation *G. lyallii*, and there are other differences, one being the "dripping point" to the leaf, at

* Trans. N.Z. Inst., vol. xxxvi (see pl. xviii).

times a most characteristic feature of this latter species. Although these distinctions are apparently trivial, they are sufficient to keep the two forms distinct from one another; and, although they may approach within a kilometre or two of one another, they are not found mixed together.*

The two veronicas, *V. traversii* and *V. leiophylla*, are not especially xerophytic. It is true they are not so hygrophytic in form as *Veronica salicifolia* and its allies, but they show no very special adaptations for the conditions of life of a subalpine scrub. On the other hand, such conditions in the scrub under consideration do not seem to require very special adaptations, and the extreme xerophylly of *Olearia coriacea* is out of place. Even the other xerophytes could endure much severer conditions; and it seems here that we have another case of what I have pointed out several times in previous papers †—viz., that such xerophytic structure is a survival from a former geological period when large areas of New Zealand were extremely arid.

Xerophytic structures are still more out of place on the floor of the subalpine scrub, and the list given above shows that such are hardly present. The only plant of special interest to be noted is the *Ranunculus lobulatus*. This was referred by Kirk to *Ran. insignis* as var. *lobulatus*, but he had never seen the flowers, and, as he showed, the leaves are very distinct from those of *R. insignis*. To my mind it is a well-marked species, and its affinities seem rather with *R. munroi* than with *R. insignis*. The leaves are large, with long but comparatively slender petioles. The laminæ are thin, reniform-orbicular, narrowly lobed, bright-green on the upper surface, pale beneath, variable in hairiness, but usually glabrous or nearly so on the upper surface, but with more or less very fine white hairs on the under surface and the petiole. Frequently the sinus at the base of the leaf is closed, and all sorts of transitions towards a peltate leaf ensue. The seedling has the first leaves quite entire, and with a cuneate base; the next leaves have an apical lobe; later leaves develop two lateral lobes, and the base becomes rounded and shows traces of a sinus. Evidently the young leaves are arrested stages of the adults. A large leaf may measure (lamina) 17 cm. by 15·5 cm., petiole 25 cm. There were a few flower-buds on some of the plants, and one had a flower nearly open. The sepals are broad, with a notched

* Cockayne, L., "On the Seedling Forms of New Zealand Phanerogams," &c. (Trans. N.Z. Inst., vol. xxxiii, p. 272, 1901).

† Trans. N.Z. Inst., vol. xxxiii, pp. 277–82, 1900; Trans. N.Z. Inst., vol. xxxvi, p. 251, 1904; and "The New Phytologist," vol. iv, No. 4, April, 1905, pp. 84, 85.

or emarginate apex, and slightly hairy. The petals are six, yellow, rounded or perhaps sometimes emarginate, obovate, 1·3 cm. by 8 mm., and at the base of each is one gland. The peduncle branches near its apex, and in the case examined was 8-flowered.

The other plants of the floor of the subalpine scrub are too well known to require any special mention. Formerly most likely the *Ranunculus* was far more common, but it can now only exist where secure from sheep. These have been pastured on Mount Fyffe for many years, and have completely changed the aspect of all the formations except those of rocks, the subalpine scrub, and the forest; in fact, up to 1,000 m. there is little, so far as the subalpine meadow is concerned, to point that it belongs to a lofty alpine range.

According to McKay* the Kaikoura Mountains are very young geologically—much younger, indeed, than the Southern Alps. Such a range might be expected to show signs of initial endemism, and this seems to be the case in regard to the *Ranunculus, Cassinia*, and perhaps *Olearia coriacea*, dealt with above. On the other hand, relict endemism should, I take it, be absent, whereas the highly specialised *Olearia insignis* is peculiar to the Kaikouras, their foothills and environs. The remarkable *Helichrysum selago* also is perhaps a similar case. But before any statement of much worth can be made on this interesting subject, careful lists require to be made of the Kaikoura plants for comparison with similar lists from adjacent more ancient mountains.

4. Summary of Results.

1. There is a distinct zone of plants between the limit of the forest and the subalpine meadow on many New Zealand mountains, consisting chiefly of xerophytic shrubs, which may be named "the subalpine scrub."

2. This formation occurs on Mount Fyffe, but differs from typical subalpine scrub in the small number of its species, and in the fact that *Cassinia albida*, a plant peculiar to that locality, is so abundant as not only to be dominant but in places almost a pure formation.

3. *Ranunculus lobulatus*, a plant also peculiar to that region, is the principal plant of the ground beneath the scrub.

4. Some of the shrubs are strongly xerophytic, especially another plant peculiar to the range, *Olearia coriacea*, while others are much more mesophytic.

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* "On the Geology of Marlborough and South-east Nelson." Reports of Geolog. Exploration during 1890–91, p. 5, 1892.

5. The amount of xerophylly in many New Zealand plants is by no means a measure of their adaptation to present environment, but is more likely a survival from a former geological period when xerophytic conditions were more widespread.

6. The vegetation of the Kaikoura Mountains appears to yield evidence both for and against McKay's theory of the extreme youth of these ranges.

5. LIST OF PLANTS OF THE SUBALPINE SCRUB.

Lycopodiaceæ.

Lycopodium fastigiatum, *R. Br.*

Filices.

Lomaria alpina, *Spreng.*

Taxaceæ.

Podocarpus totara, *Don.*

Liliaceæ.

Phormium cookianum, *Le Jolis.*

Ranunculaceæ.

Ranunculus lobulatus, *sp. nov.* = R. insignis, *Hook. f.*, *var.* lobulatus, *T. Kirk*, "*Students' Flora*," *p.* 8.

Rosaceæ.

Acæna sanguisorbæ, *Vahl, var.*
Rubus australis, *Forst. f.*, *var.* glaber, *Hook. f.*

Geraniaceæ.

Geranium microphyllum, *Hook. f.*

Tilliaceæ.

Aristotelia fruticosa, *Hook. f.*
,, colensoi, *Hook. f.*

Malvaceæ.

Gaya ribifolia, *sp. nov.* = G. lyallii, *J. E. Baker*, *var.* ribifolia, *F. v. Muell.*

Onagraceæ.

Epilobium, *sp. aff.* E. chloræfolium, *Hausskn.*

Umbelliferæ.

Aciphylla colensoi, *Hook. f.*
Ligusticum aromaticum, *Banks and Sol.*

Epacridaceæ.

Dracophyllum uniflorum, *Hook. f.*

Scrophularinaceæ.

Veronica leiophylla, *Cheesem.*
,, traversii, *Hook. f.*

Rubiaceæ.

Coprosma parviflora, *Hook. f.*
,, rhamnoides, *A. Cunn.*

Compositæ.

Cassinia albida, *sp. nov.* = *C. vauvilliersii, Hook. f., var.* albida, *T. Kirk,* "*Students' Flora,*" *p.* 315.
C. albida, *Cockayne, var.* canescens, *var. nov.*
Celmisia coriacea, *Hook. f.*
Olearia coriacea, *T. Kirk.*
,, forsteri, *Hook. f.*
Senecio geminatus, *T. Kirk* = Traversia baccharoides, *Hook. f.*, *Handb. N.Z. Flora, p.* 164.

Art. XLVII.—*Notes on the Growth of certain Native Trees in the Auckland Domain.*

By James Stewart, M.Inst.C.E.

[*Read before the Auckland Institute, 9th October,* 1905.]

Plates XLVII–LI.

The rate of growth and age of our native trees have often formed a subject of inquiry, and observers have from time to time recorded particulars, principally relating to increase in height and girth of the trees mostly used for building purposes and in the industrial arts of the colony. In vol. xx of the "Transactions of the New Zealand Institute" appears the last of three articles by the late Mr. James Baber, who took much interest in the subject, and, from his early residence in the colony, and some practice in aboriculture, was well qualified to speak on it.

In Mr. Baber's notes alluded to, written in 1887, the height and girth of three kauris, planted in the Auckland Domain in 1865, are given, the average girth at 2 ft. from the ground being 2 ft. 2 in., and average height 25 ft. This represents a diameter of $8\frac{1}{4}$ in. only, and, as the trees had been established twenty-two years, it shows an average increase of $\frac{3}{8}$ in. in diameter and about 1 ft. in height per annum, making allowance for dimensions at the time of planting. It is to be regretted that the trees so measured by Mr. Baber in 1887 were not in any way fixed for future identification. It is therefore impossible to trace the increase of growth from that time in other than a general way.

As forty years have now elapsed since these trees were planted by Mr. Chalmers in 1865, it was thought to be a good time for further inspection, and I undertook, at the request of the Council, to measure and locate for future reference the various trees in the plantation. This work, on examination, proved to be one of more magnitude than was anticipated. The plantation extends in a nearly north and south direction almost an eighth of a mile, and occupies a width in the valley of 50 ft. to 60 ft., excepting at the southern end, where the trees are more scattered. A dense undergrowth (since cleared off) rendered the work of survey all the more troublesome. In all, the positions of ninety-six pines and two rewarewas were fixed by systematic survey, and their girths measured at 2 ft. above ground. The heights of fifteen of these were accurately measured, all as existing on the 1st June, 1905.

The situation is in a comparatively sheltered valley in which is a small but permanent stream. The surface soil is dark and heavy, and is partly alluvium from the volcanic basins forming the upper levels of the domain. The subsoil is a hard yellow clay. The conditions, on the whole, are very similar to the more fertile forests, such as Waitakerei, where kauri and mixed bush are found in perfection. The trees, without exception, present a healthy appearance, and have been for forty years in the normal conditions of the "bush."

On the plan herewith is recorded the position and species of each of these trees, and their girths in feet and inches. A series of totara pegs, numbered 1 to 9, are placed, from one or other of which the distance in feet and direction of every tree is shown. The magnetic bearings and distances of the traverse pegs are given, and the whole of the observations have been plotted on strong mounted paper, enclosed in a tin case, and deposited in the Auckland Museum. This record should, in the future, and from time to time, enable any of these trees to be identified, their dimensions compared, and rate of growth determined.

The trees shown on the plan consist of—totara, 12; kauri, 18; rimu, 36; miro, 8; tanekaha, 15; kahikatea, 7; and rewarewa, 2. The only pine not represented is matai. The heights of the fifteen, as measured, average—kauri, 41 ft. 8 in., girth 3 ft. 1 in.; rimu, 44 ft., girth 2 ft. 6 in.; totara, 40 ft. 8 in., girth 3 ft. 1 in.; miro (one only), 32 ft. 10 in., girth 2 ft. 4 in.; kahikatea (one only), 43 ft. 3 in., girth 2 ft. 11 in.; rewarewa, 43 ft. 2 in., girth 3 ft.

It will be observed that, allowing for the probable size when planted, the average rate of growth for the first forty years in this location may be taken at about 1 ft. in height and $\frac{5}{16}$ in. in diameter per annum. The fifteen trees whose heights were measured are indicated on the plan by arrows, and the heights figured in feet and inches.

Some doubt has at times been expressed as to whether the rings or increments of growth as shown by the cross-sections of kauri and other New Zealand pines indicated annual growths, as they admittedly do in the deciduous trees and pines of other countries. It was deemed to be quite probable that two increments might be formed annually, especially in the case of kauri, in the subtropical north of Auckland. All analogical reasoning pointed to one very distinct increment of growth per annum, but something more conclusive was desirable. As the time of growth of the trees in question was definitely known, it was seen that an opportunity was here presented, probably unique, to determine the point. With this view, and in the objects of science, application was made last year to the then Mayor, the Hon. E. Mitchelson, for permission to cut one kauri, to be selected by Mr. W. Goldie, Superintendent of Parks. This was readily granted, and, when the time came, confirmed by His Worship A. M. Myers, Esq., the present Mayor. In selecting the tree to be cut, Mr. Goldie drew attention to the circumstance that at one place the trees were too much crowded, and suggested that one of them, a rimu, should also be cut down. The consent of His Worship the Mayor having been formally obtained, the two trees were cut on the 4th September last, and cross-sections obtained of each. The kauri was 3 ft., and the rimu 3 ft. 9 in., in girth.

The sections of the kauri show much irregularity, not only in the thickness of rings, but in the size at different places in the same ring. In some places there are eight rings to $\frac{1}{2}$ in., in others three to 1 in. On account of this irregularity and constriction, it is a matter of some difficulty to count the rings. The growth of the kauri has been exceedingly slow during the first four or five years, but there is no doubt that the section shows forty-two rings at 1 ft. from the ground, and from the eccentricity of the pith these are contained in $3\frac{3}{8}$ in. on one side and in $8\frac{1}{4}$ in. on the other. The increase of height being roughly 1 ft. per annum, one ring less will be found for every foot in height at which the section is cut.

The rimu section is much more regular and concentric. The tree had taken twelve years to reach a diameter of 2 in. This was succeeded by a rapid rate of increase during the next ten years, amounting to $\frac{1}{2}$ in. diameter per annum. During the last twenty years the rate has been less but very regular. There are in all forty-two rings, and with the exception of the first twelve they are very distinct, and the annual growth unmistakable. In several of the rings, especially in the ten larger, there are quite evident traces of subgrowths, two, three, or even four in one year.

Plate L shows the sections of both trees. The irregularity of growth and the particulars as above noted can be easily traced. The extreme constrictions of the inner 2 in. of the rimu may in part be due to compression, but the transition to a rapid rate has been very sudden. An aged rimu commonly shows a pole of hard and resinous wood, about 4 in. or 5 in. in diameter, which parts easily from the main body of the trunk. In these cores it is very difficult to distinguish the rings.

The rate of growth having, it is believed, been thus demonstrated, attention was turned to the cross-section of kauri, 8 ft. in diameter, presented to the Museum about six years ago by Messrs. Leyland and O'Brien. A sector of it was dressed and oiled, and the rings counted as accurately as possible. But the task is a difficult one. Within a small limit of error, however, there can be counted 455 annual growths, the rate varying from twenty-five per inch to seven or less. This tree had been cut in its prime, as evidenced by the extent and dimensions of healthy sapwood, which averages $6\frac{1}{2}$ in. all round, or $25\frac{1}{4}$ per cent. of the area of section. This noble kauri, then, must have been a vigorous sapling on the slopes of Mangawai before the Wars of the Roses. And from the same data we must conclude that there are kauri-trees still in good condition whose ages date from the early centuries of our era.

Plate LI shows totara and a small rimu and kauri, and is from a photograph by Mr. Joseph Martin.

ART. XLVIII.—*On the Leaf-structure of some Plants from the Southern Islands of New Zealand.*

By MISS E. M. HERRIOTT, M.A.

[*Read before the Philosophical Institute of Canterbury, 5th July, 1905.*]

Communicated by Dr. Charles Chilton.

Plates XXVIII–XXXVII.

THE Southern Islands of New Zealand consist of several groups of small islands—namely, The Snares, Auckland Islands, Campbell Island, Macquarie Island, Antipodes Islands, and Bounty Islands—lying in the South Pacific Ocean between the parallels of 54° 44′ and 47° 30′ south latitude, and 159° 49′ and 179° east longitude. They all lie in a more or less southerly direction from the South Cape of Stewart Island, the southernmost point of New Zealand. The Snares are 60 miles to the south-west, the Auckland Group 190 miles south by west, Campbell Island 330 miles south by east, Macquarie Island 570 miles south-west by south, the Antipodes Islands 490 miles east-south-east, the Bounty Islands 490 miles east.

These islands present an exceedingly interesting flora for the study of the botanist. First, it occupies an important position because of the light it throws upon the history of the flora of New Zealand itself. Dr. Cockayne (1903) considers that here are preserved remnants of an old vegetation which at one time spread more widely over the whole of New Zealand, and also further south in previous land connections. Now, whatever may have been the case in past ages, these islands are far removed from any other large tracts of land, and consequently, where natural conditions have not been disturbed, they retain their primitive flora intact.

Again, in certain parts, especially on Campbell Island, man has recently made settlements and introduced a disturbing element by seeking to " reclaim " certain portions of the island. Here, then, is afforded to the botanist an excellent opportunity of finding out " the general laws that govern such vegetation-modifications, for the gradual changes from purely virgin formations to final reclamation can be observed and the factors bringing this about noted."* Then, again, these islands are the homes of certain remarkable plants which are found here and nowhere else, such as *Stilbocarpa polaris*, the species of *Pleurophyllum*, and *Olearia lyallii.*

The only opportunity the botanist has of visiting these islands—excepting, of course, the special opportunities afforded by scientific discovery expeditions—is by accompanying the Government boat on her trip round the outlying lighthouses and islands to leave stores, &c. This trip is made twice a year, once in winter and again in summer. The weather is often very rough and makes landing difficult; Snares Island is sometimes not visited for this reason. Then, again, on a trip such as this the time allotted to each stopping-place is necessarily very limited, and much has to be done in the way of making notes, collecting material, &c., in an all-too-short time.

Previous to 1903 the botanical visits to the islands had all been made during the summer trip of the boat, and there are several accounts of the summer aspect of the vegetation from various botanists, the fullest being by the late Professor T. Kirk.†

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* Cockayne (1903), p. 301.

† " On the Botany of the Antarctic Islands " (1891).

Last year, however, Dr. Cockayne accompanied the boat on its winter trip, and the results of his investigations have been published in the "Transactions of the New Zealand Institute."* This paper gives much the fullest description of the different plant formations, as regards their nature and extent, and is a very valuable addition to the history of the botany of New Zealand. There is some detail given of the more important plants concerning their adaptability by their structure to their surroundings, and in some cases a hasty description of the anatomical structure is given. In this paper I propose to go more fully into the anatomical structure of the leaves of certain of these plants, to show in what way the plant adapts itself to meet the peculiar conditions of the climate. The leaf is the organ chiefly affected in cases of this kind, since the most urgent need of the plant is that it should be able to obtain or retain a sufficient supply of moisture. This induces the so-called xerophytic characters which are mainly met with in the leaf.

The material on which I have been able to work has been growing ready to my hand. Dr. Cockayne, during his visit to the islands, succeeded in making a very valuable collection of living plants, and this he has very kindly presented to the biological laboratory of Canterbury College for its rockery. The rockery was built last year, under Dr. Cockayne's supervision, for the cultivation of alpine plants. It is situated on the south side of the laboratory, and is thereby protected to a considerable extent from the sun. The plants of the Southern Islands have been placed on the shadiest portion of the rockery, so that they will get very little sun indeed. This, as will be seen from the description of the climate prevalent on the islands, is a necessary factor to insure their satisfactory growth, for we find that the sun is seldom seen there. Most of the plants have taken very kindly to their new surroundings, and are flourishing well; some few have been unable to maintain an existence in the absence of certain peculiar characteristic constituents of their habitat, and have perished.

In all, twenty-nine species of flowering-plants were examined, a list of which is given later on. This was all I had time to examine, and includes most of the species on the rockery. The more important and striking of the plants I have endeavoured to describe more fully.

In a study of this nature there are two factors which must be considered as most important in determining the character of the plant: these are (1) the climate, and (2) the soil.

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* "A Botanical Excursion during Midwinter to the Southern Islands of New Zealand."

1. *Climate.*—All the islands seem to resemble one another very closely in respect of climate. First of all, Hooker notices, in his "Flora Antarctica" (vol. i, xi), "that the vast proportion which the water bears to the land tends to render the temperature more uniform throughout the year—the further south the position the more equable the climate seems to be. . . The power of the sun is seldom felt, and, unless in the immediate neighbourhood of land and accompanied by a comparatively dry wind, that luminary only draws up such mists and fogs as intercept its rays. . . . All the islands to the south of 45° partake more or less of this inhospitable climate, which, though eminently unfavourable to a varied growth of plants, still, from its equable nature, causes a degree of luxuriance to pervade all the vegetable kingdom, such as is never seen in climates where the vegetative functions are suspended for a large portion of the year."*

The climate of the Auckland Islands, he says, is "rainy and very stormy" (p. 2). Dr. Cockayne sums up the features with regard to the climate of the Auckland Islands as follows: "(1) There are a great number of rainy days; (2) the moisture, which can easily permeate the peaty soil, will not readily evaporate owing to the almost constant cloudy skies, these also tending to keep the air full of moisture; (3) there are very frequent winds, sometimes of great violence, accompanied by rain or sleet; (4) the winter climate is extremely mild—much milder, indeed, than that of certain parts of the South Island of New Zealand at sea-level, as, *e.g.*, the Canterbury Plains" (pp. 235–6).

The climate of Campbell Island is very similar: "There is the same lack of sunshine and similar frequent gales accompanied by driving rain and sleet, especially in spring and autumn. . . . Sunshine is most frequent during the summer months. . . . The snowfall at sea-level is very slight . . . comes in blasts from the south-west, while these gales are frequently accompanied by hail. . . . In the 'subalpine region' the frost is much stronger . . . there was no general covering of snow . . . such frosts . . . subject these plants to comparatively severe conditions" (p. 268). Here are found, amongst other plants, *Coprosma repens, Epilobium confertifolium, Phyllachne clavigera.*

"As for rain, really heavy rain is not very frequent; usually it is a fine drizzle. In short, there must be a great number of rainy days, but no excessive annual rainfall" (p. 269).

"With regard to the climate of the Antipodes Island, I should imagine that it is very similar to that of the other South-

* Hooker (1847), "Summary of the Voyage," vol. i, xi.

ern Islands—cloudy skies, frequent showers, a mild temperature in winter but a cool summer, and, finally, furious gales and squalls with hail or sleet, of which winds the nature of the arborescent plants bears abundant evidence" (p. 285).

On the Bounty Islands there is no vegetation except "an alga clothing the rocks and giving them a greenish hue in places, and on the rocks a mass of a peculiar species of *Durvillæa*" (p. 297). The prevailing conditions of climate are therefore well summed up in the above description of the climate of Antipodes Island.

The temperature is pretty uniform throughout the entire year, and active growth is possible for the greater portion of the year. There is very little sunshine, the sky being usually cloudy, and when there is no actual rain the atmosphere will contain considerable moisture. All the islands are subject to rather severe gales, and this has an effect on the number and appearance of the ligneous plants present. On Snares Island and Auckland Islands there is a pretty extensive forest formation, but on Campbell Island, in consequence of severer winds, it is merely a scrub formation; on Antipodes Islands the scrub is even less developed, while on Macquarie Island there is none at all.

2. *Soil.*—The second important factor which influences the form and structure of plants is the nature of the soil in which they grow; and we find the different soils characterized by different formations or associations of plants in which some one plant or more predominates and gives its especial character to the formation. Here, again, following Dr. Cockayne's classification, we get the following formations: (1) Sand-dunes, only on Auckland Island; (2) coastal rocks; (3) forest in Auckland Islands and Snares, scrub in Campbell and Antipodes; (4) lowland tussock; (5) meadow formations; (6) bog in Antipodes Islands; (7) subalpine—(*a*) meadow, (*b*) rocks.

Full details of these formations are to be found in Dr. Cockayne's paper of 1903 (p. 226).

The soil in which these plants of the Southern Islands find themselves situated is therefore generally of a moist peaty nature, and not one which at first sight calls for modifications to check the amount of water transpired; but an examination of the chemical composition of such a soil shows that it must necessarily consist of various salts, which the water to be taken into the roots will dissolve. In swampy districts, also, there is a great percentage of humic acid present, and this is harmful when taken into the tissues of the plants. In the first case, "salts that are dissolved by the water in the soil influence the osmotic processes, and consequently the absorption of water."* This is just a natural application of the laws ruling the phenomenon of osmosis. When the root absorbs water with difficulty it is necessary to reduce the amount transpired from the leaves, and hence those modifications of the leaf to check transpiration. The soil is also usually poor in oxygen, and this added to its acid character renders absorption of water difficult, and again necessitates the xerophytic character in the leaf. "The water-capacity of a given soil does not enable us to judge of the quantity of water that a certain plant is capable of taking from it."*

In considering the adaptability of the plants to their environment, I will first of all deal briefly with some common features of external form which aid the plant in its struggle.

The strong winds to which certain parts of the islands are subjected must necessarily have a corresponding effect in determining the nature of the plants. Thus, for instance, there is an absence of any arborescent species on Campbell Island and Antipodes Islands, where there is greater exposure to such gales than on the Snares and in the Auckland Group. The trees that are present show the direction from which the winds come in the stunted branches on the windward side. The small species of the *Coprosmas* which occur on all the islands except Macquarie and Bounty Islands show the tendency to avoid exposure to the winds by their prostrate habit. Amongst the herbaceous plants, a large proportion form rosettes of leaves, which, pressed closely to the substratum, are able to resist the dislodging effects of furious gales. The huge plants of *Pleurophyllum* have adopted this habit, and form wide-spreading rosettes "which cover acres." The smaller genera, *Abrotanella*, *Cotula*, *Gentiana*, *Myosotis*, and *Plantago*, may also be classed here. Others have prostrate stems creeping over the ground and rooting at intervals; amongst these may be mentioned *Epilobium*, *Cotula*, and *Pratia*. Others, again, as the grass-like forms, *Luzula*, *Scirpus*, *Carex*, and *Poa*, are able to withstand any ill effects from the wind by their thin, linear, and pliant leaves. The larger herbaceous plants, as the two species of *Ligusticum* and the large-leaved *Stilbocarpa*, are able by the stout and firm structure of their leaves to resist the wind.

The modifications of the leaf itself to check transpiration may be enumerated as follows (following chiefly Kearney's classification, 1900, p. 279):—

(1.) A reduction in the transpiring surface, in the two species of *Coprosma*.

(2.) The position of the transpiring surface — modification

* Schimper (1903), p. 85.

common in the grasses and sedges, also in *Astelia* and *Luzula*, and in the spiral leaves of the young shoots of *Epilobium*. Under this head also may be classed the peculiar cushion-like plants of *Colobanthus* and *Phyllachne*.

(3.) The anatomical modifications of the epidermis of the leaf itself. (*a.*) A well-developed cuticle. This may be smooth or strongly wrinkled. A wrinkled cuticle serves the purpose of reflecting the light-rays, so that they do not strike down directly on to the chlorophyll tissue below. Such a cuticle is found in *Ligusticum* and *Coprosma*, amongst others. In *Acæna* and *Poa foliosa* the same purpose is answered by the peculiar outgrowth of the epidermal cells into short papillæ, which are provided with greatly thickened outer walls. (*b.*) The great development of hairs as outgrowths of the epidermal cells (*Myosotis*, *Olearia*, *Ranunculus*, &c.), or of the deeper tissues, as in *Stilbocarpa*. (*c.*) The position of the stomata.

(4.) Succulence of the leaf. "A succulent plant loses water much less readily, since the water-tissue gives up its supply reluctantly. In some cases succulence is due to the presence of mucilaginous slime in the cells of the water-tissue, which greedily absorbs and tenaciously retains water."* Here may be classed the bog xerophytes, *Colobanthus subulatus* and *Phyllachne clavigera*, and also *Epilobium*, *Ranunculus pinguis*, *Myosotis*, and *Astelia*.

(5.) Structure of the chlorenchyma. In the majority of the plants examined the palisade tissue was strongly developed, consisting of from two to three layers. In *Ligusticum antipodum*, *Phyllachne*, *Astelia*, and *Scirpus* it is not developed, but its place is occupied by a more or less compact tissue composed of rounded cells, which probably acts in something the same way.

(6.) Presence of oil. Oil-globules are found in the mesophyll tissue, and sometimes in the epidermal cells of the two species of *Coprosma*, *Olearia*, *Veronica benthami*, and *Astelia*. It has been suggested that the secretion of ethereal oils aids the plant in resisting the ill effects of a heated atmosphere, since "minute quantities of such oils diffused through the air are capable of arresting radiant heat."†

(7.) Another modification of interest in the leaf-structure is the development of stereom tissue. This is seen best in the species of *Ligusticum*. It gives rigidity to the leaves, and probably is a protection against the mechanical effects of the wind. In some other species it is developed in connection with the vascular bundles, as in *Acæna*, *Epilobium*, *Olearia*, *Luzula*, and

* Kearney (1901), p. 367.

† See Henslow (1895), p. 82.

Carex trifida, and it has been suggested that here it is probably a protection against loss of water by evaporation from the vessels.* In *Ligusticum* it is further reinforced by the development of collenchyma, usually in connection with the epidermis. Pierce (1903, p. 124) considers that this collenchymatous tissue is primarily formed as strengthening-tissue in young growing organs, and is afterwards made use of as water-storage tissue, by holding the drops of water in the interstices of the cell-walls.

(8.) Colourless parenchyma tissue, which probably acts to store water, is present in *Ranunculus pinguis*, and occupies the greater part of the tissue of the succulent plants, as *Colobanthus* and *Phyllachne*. It is also specially developed in *Astelia*. Calcium oxalate is developed in certain of the plants. In *Colobanthus* it takes the form of clusters of crystals, while in *Epilobium* and *Coprosma repens*, belonging to the Dicotyledons, they are needle-shaped crystals formed in groups as raphides; raphides are also present in *Astelia*. Raphides are usually associated with mucilage secretion.†

Ranunculus pinguis, Hook. f.

"Radical leaves on short stout petioles, fleshy, rounded, reniform, deeply crenate, lobulate, 1 in. to 3 in. in diameter, veins reticulated in young plants, oblong and cuneate; cauline more or less cut."‡

Hab.—"Boggy places on hills, 1,000 ft. above sea to mountain-tops on Campbell Island, and rare in rocky places on Lord Auckland's Island."§

Dr. Cockayne (1903) mentions it only once in his account of the Campbell Island flora. He says (p. 283) that it is more or less plentiful in the rich peaty soil of the wind-sheltered hollows of the subalpine rock region. Such a station as this, he adds, "is very favourable for plants, since the very conditions are here present which experience had found essential for the cultivation of difficult alpine plants—viz., shelter, a porous soil, abundance of pure water, perfect drainage."

R. subscaposus, another plant of the Southern Islands, occurs in this same subalpine rock region, but under less favourable conditions. Both it and another species, *R. aucklandicus*, are flourishing well on the rockery at the present time, while *R. pinguis* has now entirely disappeared. The leaf I examined was very young, only about ½ in. in diameter, and did not show the

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* Kearney (1900), p. 282.
† Strasburger (1898), p. 72.
‡ Hooker (1867), p. 4.
§ Hooker (1847), vol. i, p. 3.

form of the adult leaf, but its anatomical structure is probably very similar. Young as it was, it presented some striking points of difference from the older leaves of the other two species, especially as regards its succulent habit.

Anatomy (figs. 1*a*, 1*b*).—There is a very thick but smooth cuticle (*cut.*) on the upper surface which gives the leaf its shiny appearance. Below this comes the upper epidermis (*ep.*), with its large and thick-walled cells interrupted at frequent intervals by stomata (*st.*). The walls are collenchymatous, staining blue on the application of chlor-zinc-iodine. The cells of the lower epidermis (*l.ep.*) are somewhat smaller and not so thick-walled. No hairs are present. The chlorenchyma (*chlor.*) is differentiated into palisade (*pal.*) and spongy (*sp.*), the spongy parenchyma occupying the greater area. The palisade tissue consists of the ordinary palisade cells in 3–4 layers, densely filled with chlorophyll corpuscles, giving the leaf its characteristic dark-green colour. In this young leaf the palisade tissue was continued in two layers above the small vascular bundles (*v.b.*) which occurred scattered through the spongy tissue. In the other two species the vascular bundles interrupt the green chlorenchyma with a mass of colourless cells. The spongy tissue (*sp.*) is very loosely arranged, leaving large air-spaces between the cells. In the central portion of the leaf the cells are large and sparingly filled with chlorophyll; some occur as colourless thin-walled parenchyma cells (*par.*). Adjoining the lower epidermis, however, the cells are much smaller and round, and also more abundantly filled with chlorophyll. The vascular bundles (*v.b.*) are each surrounded by a more or less sharply defined endodermis (*endo.*), and this is again surrounded with a layer of larger thin-walled and colourless parenchyma (*p.s.*) cells. Each bundle consists of xylem (*xy.*) on the upper surface and phloem (*ph.*) on the lower.

Here the effects of the moist or semi-aquatic habitat are seen in the development of larger air-spaces.

Ranunculus subscaposus, Hook. f., Fl. Antarc., i, 5.

"Radical leaves on slender petioles, 3 in. to 8 in. long, blade broadly triangular-ovate, slightly cordate, 3-foliate or 3-partite to base; leaflets cuneate at the base and more or less deeply incised or toothed, or rarely entire with margins deeply cut; cauline similar."*

"Both petiole and lamina on both surfaces are densely clothed with appressed whitish hairs."†

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* Kirk (1899), p. 15.
† Cockayne (1903), p. 273.

Hab.—Campbell Island, "by margins of rivulets in the woods."*

This plant has so far, like *R. pinguis*, been found only on Campbell Island. Is is found in great abundance by the side of the small streams running through the *Dracophyllum* scrub formation.† It occurs also in the moist peaty soil of the *Rostkovia* formation, and in the peaty hollows of the subalpine rock region (p. 282). The leaf differs from that of *R. pinguis* in thickness, being a little less than half. This is brought about by a reduction in the number of layers of palisade and spongy parenchyma. Another point of difference is the presence of unicellular hairs on both surfaces of *R. subscaposus*. This reduction in tissue is no doubt a direct consequence of the poorer nature of its habitat. This would also account for its wider distribution, and the ease with which it adapts itself to its new surroundings.

Anatomy (figs. 2*a*, 2*b*, 2*c*).—There is no cuticle distinguishable in this species. The upper epidermis (*ep.*) consists of large but thin-walled cells, some oblong, others cubical in transverse section. Hairs (*h.*) are present on both surfaces as unicellular prolongations of the epidermal cells, while the cells around the hair are arranged in a radiating manner, radiating outwards from its base (fig. 2*b*, *ep.*). The lower epidermis (*l.ep.*) is composed of smaller cells, interrupted by numerous stomata (*st.*), which occur on this lower surface alone—another point of distinction from *R. pinguis*. The stomata project slightly from the surface of the leaf. The chlorenchyma (*chlor.*) is differentiated into palisade (*pal.*), consisting of one layer of large cells, widest at their junction with the upper epidermis, but gradually becoming narrower as they adjoin the spongy tissue (*sp.*). This is loosely arranged in 2–3 layers, and consists of smaller cells—some oblong, with their axis parallel to the surface of the leaf; others bordering on the lower epidermis are smaller rounded cells densely filled with chlorophyll. The air-spaces (*a.s.*) left between the cells of this tissue are also large and frequent. The main vascular bundles (*v.b.*) are situated beneath depressions of the upper leaf surface, and interrupt the chlorenchymatous tissue with their surrounding colourless cells. The smaller veins are scattered throughout the chlorenchyma. An endodermis (*endo.*) and parenchyma sheath (*p.s.*) can usually be recognised.

Ranunculus aucklandicus, A. Gray.

"Radical leaves strigose-hirsute, on slender petioles, 3 in.–5 in. long or more, slightly sheathing at the base, rounded reniform or the upper rounded truncate or almost subcordate, 1 in.–1½ in.

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* Hooker (1864), p. 7.

† Cockayne (1903), p. 273.

in diameter, 3-cleft to or beyond the middle, mostly with a closed sinus, the broad lobes again 2–3-lobed or coarsely toothed."*

Hab.—" Auckland Island, 1,800 ft." (Kirk).

This plant is included in Kirk's account of the Campbell Island flora published in the New Zealand Transactions of 1881 (p. 387). There is no description of it in Dr. Cockayne's paper, but as there was a plant growing on the rockery I examined it for the sake of comparison with the other two species. It resembles most closely *R. subscaposus.*

Anatomy (fig. 3.)—There is no cuticle on either surface, and the cells of the lower epidermis (*l.ep.*) are slightly larger than those of the upper (*ep.*). There are stomata (*st.*) on both surfaces in this case, and long thick-walled unicellular hairs (*h.*). It resembles *R. pinguis* in having stomata on both surfaces, but *R. subscaposus* in all other respects, as, for instance, in the thickness of the leaf, presence of hairs on both surfaces, and absence of cuticle. The chlorenchyma (*chlor.*) is differentiated into palisade (*pal.*) of one layer, consisting of cells not so large as those of *R. subscaposus*, and spongy of 3–4 layers of elongated cells about twice as long as broad, arranged very loosely so as to leave numerous air-spaces (*a.s.*). This loose arrangement of spongy tissue is a characteristic feature of all these three species of *Ranunculus*, and is doubtless a direct result of the moist or semi-aquatic habitat,† to insure a sufficient aeration of the chlorophyll-containing cells of the chlorenchyma, without which assimilation is checked. The main vascular bundle, as in the case of *R. subscaposus,* lies below a depression of the upper leaf surface, and below it the lower epidermis (*l.ep.*) is strengthened by a double layer of collenchymatous cells (*col.*).

Colobanthus subulatus, Hook. f.

" A small, moss-like, densely cæspitose, perfectly glabrous plant, with subulate, rigid, shining leaves, forming tufts 1 in. high. Leaves densely imbricated, about $\frac{1}{6}$ in. long, with acicular points, grooved above, convex on the back."‡

" This plant forms small, convex, round, dense, soft cushions, about 5 cm. in diameter. At the ends of each shoot are 6–8 stout green leaves, about 7 mm. in length, the base membranous and sheathing, the apex acicular. The upper surface is channelled. Below the terminal green leaves the shoot-axis is clothed with the old leaves of previous years."§

* Kirk (1899), p. 16.
† Henslow (1895), p. 144.
‡ Hooker (1867), p. 25.
§ Cockayne (1903), p. 284.

Hab.—"Campbell's Island; in rounded tufts on rocks near the summit of the hills, at altitude 1,000 ft.; of rare occurrence, and confined to the tops of the hills on Campbell Island; nowhere seen in Lord Auckland Group. In the Falklands, and in Fuegia where it was discovered by Banks and Solander, it is very common, both on the low grounds and on the mountains."*

This is one of the small rock-plants which find a habitation in the crevices of the rocks where a small amount of peat has been able to collect, while the moisture of the atmosphere makes life possible (fig. 4*b*).

The other species, *Colobanthus muscoides*, from which this one differs by being rigid and more pungent,* is more widely distributed throughout the islands. Below the green leaves of this species—that is, in the centre of the cushion—"the old leaves are all in a greater or less advanced stage of decay, and form a dense, yellow, sticky, peaty mass, about 10 cm. in depth, through which the shoot-axes penetrate, giving off at the under surface of the cushion a large number of fine roots. The peaty mass absorbs water like a sponge, and in the wet climate must nearly always be saturated with moisture."†

In its natural habitat it is probable that *Colobanthus subulatus* behaves in the same manner, but on the rockery, where the conditions under which it has to live are not so stringent, the older leaves have not degenerated into the "sticky, peaty mass." That it still maintains many of its xerophytic characters may be seen on a study of its anatomical structure.

Anatomy (figs. 4*a*, 4*b*).—There is firstly a thickened but unwrinkled cuticle, then come the epidermal cells, on the upper surface (*ep.*) very thick-walled but flattened, and on the convex side (*l.ep.*) still with thickened walls, but larger and more cubical in shape. There are numerous small stomata (*st.*) on the upper surface, with a few on the convex side just near the upper epidermis. The chlorenchyma (*chlor.*) may perhaps be said to be differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade is found in three layers of small elongated cells on the upper surface, and for a greater or less distance is continued down the sides of the convex portion of the leaf. The rest of the leaf is composed of larger cells, more or less round in shape, containing very little chlorophyll. The chlorophyll is mostly confined to the palisade cells. There are two or three vascular bundles (*v.b.*) enclosed in a large thin-walled parenchyma sheath (*p.s.*) and imbedded in a mass of colourless thin-walled parenchyma (*par.*).

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* Hooker (1847), p. 13.
† Cockayne (1903), p. 242.

Acæna sanguisorbæ, var. antarctica.

"The leaves are pale-green, but not whitish-green as those of *A. sanguisorbæ* var. *pilosa*, glabrous on upper surface but with many adpressed hairs on under surface. It may be distinguished at a glance from *A. sanguisorbæ* var. *pilosa* by the general aspect, which is chiefly brought about by the colour of the leaves,"* &c.

Hab.—This plant is found in Lord Auckland Group, on Campbell Island, and also on Antipodes Island. On Auckland Island it forms part of the *Pleurophyllum* meadow formation, "trailing over the surface of the ground very abundantly in long shoots with its characteristic pale-green leaves."†

On Campbell Island, where the land has been cleared for various purposes a new formation has arisen, and its most prominent member is *Acæna sanguisorbæ antarctica*, which is spreading so rapidly as to become a weed in the eyes of the farmer.

On Antipodes Island, again, it is spreading very rapidly. The albatros is very abundant on this island at certain times of the year, and where its nest occurs the primitive vegetation round has been destroyed. Dr. Cockayne found that "in nearly all cases *Acæna* and *Stellaria* were the first plants to make their appearance" (p. 299) in repopulating the bare places. The young albatros helps to distribute the plant. The seeds are matted in the down on its breast, and as it pushes its way down to the water they are rubbed off or scattered in the down. This plant forms a prominent feature of the tussock meadow, "climbing in thick masses over grass and fern" (p. 293).

On the rockery it is flourishing well, growing over the stones and other smaller plants, and, by reason of its large and peculiarly tinted leaves, forming quite a prominent member. Hairs are present on the lower surface of the leaf opposite the midrib and the more important veins, and also as small tufts at the apex of each tooth of the serrate margin.

It is quite distinct from *A. sanguisorbæ pilosa*, which is growing next it on the rockery—quite an insignificant member, completely overshadowed by its larger-leaved relative. The anatomical structures of the two present striking points of contrast, as may be seen by referring to figs. 5*a* and 5*b*.

Anatomy (figs. 5*a*, 5*b*, 5*c*, 5*d*, 5*e*).—There is no distinct cuticle, but the outer walls of the epidermal cells (*ep.*) of both surfaces bulge out to form short papillæ (*pap.*), and the outer walls of these cells are considerably thickened (*ep.*). In *A.*

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* Cockayne (1903), p. 319.

† Cockayne (1903), p. 259.

sanguisorbæ pilosa there are no papillæ, but the outer walls are straight (fig. 5*d*). The papillæ in this case probably serve the same purpose as the wrinkled cuticle of other plants, to reflect the light. They also affect the colour of the leaf. Stomata (*st.*) occur on the under surface, and are partially covered by the projecting papillæ of the neighbouring cells. The chlorenchyma (*chlor.*) is very sharply differentiated into palisade (*pal.*) and spongy (*sp.*), each consisting of two layers of cells. The distinction between the two tissues is so marked that a straight line parallel with either epidermis could be drawn between the two. In this respect also it differs from var. *pilosa*, where the two tissues pass gradually one into the other (fig. 5*d*). The palisade (*pal.*) consists of ordinary elongated cells with numerous chlorophyll corpuscles arranged along the side walls. The spongy tissue (*sp.*) is made up of regularly rounded cells with the corpuscles arranged on the upper and lower walls as seen in transverse section, usually 5 in each cell (fig. 5*e*). The chlorenchyma is interrupted at intervals by bands of colourless parenchyma cells (*par.*) enclosing the smaller vascular bundles (*v.b.*). The large midrib is found in the keel of the leaf surrounded by a mass of rounded and colourless parenchyma cells.

Epilobium confertifolium, Hook. f.

" Stem slender, creeping, ascending at the tips. Leaves small, suborbicular, densely foliaceous. Leaves opposite, often imbricating, rather fleshy, glabrous or glabrate, obovate-oblong, obtuse, shining, with few minute teeth, narrow at the base into a short broad sheathing petiole ; minute hairs on the lower surface."*

" A creeping plant, frequently forms rather dense patches on the surface of the ground ; the old shoots are prostrate and dorsi-ventral, the leaves inserted on their flanks, the young shoots are raised above the ground, and the leaves are in a spiral. Roots about 4·6 cm. in length are given off here and there from the prostrate stem."† (See fig. 6*b*.)

Hab.—" On grassy banks and in moist places."‡ It is found on Auckland Island, growing on the sand-dunes and also on the shady sides of the gullies between them, extending to the top of the dunes, in association with a close turf of moss. " These dunes are traversed by deep gullies down which small streams of water flow, the drainage of the swampy ground above. These furnish plant-stations of considerable shade and moisture" ; and

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* Kirk (1899), p. 171.
† Cockayne (1903), p. 238.
‡ Hooker (1847), p. 11.

it is here that *Epilobium* flourishes well.* It also occurs in the *Pleurophyllum* meadow of Auckland Island.

In Campbell Island it is mentioned in the subalpine tussock meadow, where the climate is much more severe than in the lower regions, owing to colder and longer frosts, greater exposure to the winds, to the smaller amount of sunshine, and almost constant presence of mist (p. 278). On the rockery this plant is spreading rapidly over rocks and soil, forming large patches of dark-green.

The change from spiral to dorsi-ventral arrangement of the leaves on the stem is very interesting. The creeping habit is a distinct advantage to the plant in its home on the sand-dunes, for by this means it is able to obtain a firm hold on the somewhat unstable surface; the leaves are then so twisted as to be exposed directly to the vertical rays of the sun when it shines on them, and they are further protected by a thick cuticle on the upper surface. The younger leaves, on the other hand, are more sensitive, and, being arranged spirally, catch the rays obliquely; and, as a further protection, anthocyanin is present in some of the epidermal cells. On the bleaker subalpine meadow of Campbell Island the creeping habit is also of great advantage in protecting the plant from the winds.

The leaf-anatomy of the younger and older leaves does not differ in any striking way, except in the presence of a cuticle in the older leaves which is absent in the younger ones, and in the presence of anthocyanin in the epidermal cells of the younger leaves.

Anatomy (figs. 6*a*, 6*b*).—The epidermal cells (*ep.*) consist of one layer of rather cubical cells, protected in the older leaves by a thickened but smooth cuticle. The transverse walls of the cells are thin. Stomata (*st.*) occur on both surfaces, projecting slightly from the surface. The chlorenchyma (*chlor.*) is differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade (*pal.*) consists of three layers of oval-shaped cells, almost as broad as long, closely packed except beneath the stomata, and densely filled with chlorophyll corpuscles. The spongy (*sp.*) tissue is very loosely arranged with numerous intercellular spaces (*a.s.*); frequently chains of cells run parallel to the surface (see fig.). There are about six layers of these cells, and all are sparingly filled with chlorophyll. Bundles of raphides (*r.*) occur in certain of these cells. The chlorenchyma is interrupted by the mass of thick-walled collenchyma (*col.*) surrounding the main vascular bundle (*v.b.*), and beneath it is a mass of rounded parenchymatous

* Cockayne (1903), p. 237.

cells, filling up the ridge on the lower side of the leaf. This ridge is further strengthened by a double layer of thick-walled epidermal cells (*l.ep.*).

Ligusticum latifolium, Hook. f., Handbook.

" Radical leaves 1 ft. to 2 ft. long or more ; petioles sheathing at the base, sheath shortly ligulate, blade ovate excessively coriaceous 2-pinnate, segments obliquely cuneate below, with broad winged bases, unequally 3–5-lobed, lobes acuminate with acute points and thickened margins."*

" Lateral segments not flat, but bent inwards, bringing the two surfaces into proximity, and the upper half in a vertical position with regard to light."†

Hab.—Lord Auckland Group and Campbell Island ; abundant in moist places.‡

On Lord Auckland Islands it occurs " on the stony beach of Adam's Island, abutting on the *Pleurophyllum* meadow, and not much exposed to the sea-spray " (p. 240) ; also in the *Pleurophyllum* meadow itself it is found in splendid profusion owing to the favourable nature of the peaty soil, which is adapted for plant life. The peat is formed by the decaying leaves of *Pleurophyllum*, which afford a home for many earthworms. This causes a richer supply of oxygen in the soil, and a diminished quantity of humic acid.

On Campbell Island it is found also right down to the rocky shore, and in the adjoining *Dracophyllum* scrub. This formation is broken up by deep gullies through which flow small streams of water, and these are filled up with dense masses of *Ligusticum latifolium*, *Lig. antipodum*, and *Stilbocarpa polaris*.

Anatomy (fig. 7).—There is a very thick and wrinkled cuticle (*cut.*) extending above the epidermis of the leaf. When stained with chlor-zinc-iodine it gives the distinctive yellow colour of cutin. The epidermis (*ep.*) consists of a single layer of thick-walled cells, more or less flattened. Stomata (*st.*) (fig. 8*c*) occur only on the lower epidermis (*l.ep.*). Below the epidermis comes a very strongly developed stereom (*sm.*), mixed with collenchyma tissue (*col.*), which gives a blue colour with chlor-zinc-iodine. On the upper surface this tissue may be 3–4 cells in thickness of rather large cells, and on the lower it is only 2 cells thick at most, and the cells are much smaller. At the edges the leaf stereom tissue is again found attaining a thickness in many cases of 0·33 mm., and it is the chief constituent of the tissue of the

* Kirk (1899), p. 200.
† Cockayne (1903), p. 262.
‡ Hooker (1864), p. 94.

acicular points at the ends of the lobes. The stereom is developed in groups consisting of cells with highly translucent cell-walls and very small lumina, represented in fig. 8*b* by small black strokes. This tissue has been developed to give rigidity to the leaves, to enable them to resist the fierce winds to which they are exposed, and to protect the delicate chlorophyll tissue below. In this way "it performs functions quite similar in many respects to those of the bony skeleton of higher animals."* At intervals this strengthening tissue interrupts the chlorenchyma and occupies the whole width of the leaf surrounding the vascular bundle (see fig. 7). The chlorenchyma is differentiated into palisade and spongy tissue, and is more or less separated into strands by the stereom tissue, as mentioned above. The palisade tissue (*pal.*) is from 3–4 layers thick, and consists of rectangular cells about twice as long as broad, with the chlorophyll usually on the vertical or side walls. The spongy tissue (*sp.*) is composed of smaller rounder or oval-shaped cells, occupying twice the area that the palisade does, and leaving numerous air-spaces. Just above the lower epidermis come two layers of very much smaller cells densely filled with chlorophyll. The vascular bundles are found surrounded by the stereom tissue (*sm.*). The smaller veins are frequently imbedded in the palisade tissue with a surrounding mass of stereom. The canals (*c.*) common to this order above (*Umbelliferæ*) are found both above and below the larger veins. They are bordered by a layer of epithelial cells (*b.*), which are usually empty, but may contain granular protoplasm. Fig. 8*b* shows one of these canals enlarged.

Ligusticum antipodum, Hook. f., Fl. Antarc., i, 17, t. 9, 10.

"Blade oblong or broadly oblong, 2–3-pinnate, coriaceous, dissected into countless narrow, linear, subulate segments, $\frac{1}{4}$ in. broad, with acicular points."† On the lower surface of each segment is a ridge corresponding with a depression on the upper surface, just above the midrib (see fig. 8*a*).

Hab.—Lord Auckland Islands and Campbell Island; marshy places.‡

In Lord Auckland Group it occurs in the *Pleurophyllum* meadow with *Lig. latifolium*, "their stout rhizomes and huge rigid leaves stopping the progress of pedestrians."§

In Campbell Island it is found with *Lig. latifolium* and *Stilbocarpa polaris* in the small streams running at the bottom of the

* Detmer Moor (1898), p. 518.
† Kirk (1899), p. 200.
‡ Hooker (1864), p. 94.
§ Cockayne, p. 258.

gullies between the hills. It occurs again in the subalpine rock region. On the face of a precipitous rock facing north-west it grows in the chinks of the rock. Here it is very much smallei and has stiffer and more coriaceous leaves than when growing as a meadow plant. Then, it is found again on the wind-swept summit, and again on another rock "dripping with water and densely covered with mosses and liverworts." Here the bases of the leaves are densely sheathed with old leaf-bases. "The leaves arch upwards and outwards radially, with the result that many of the stiff needle-like pinnæ are almost vertical and others horizontal. Each primary leaflet finally arches downwards. In a position such as this the conditions, although on a rock, are not very different from those of a bog, except that the water will be distinctly more pure."* The drooping habit thus described seems characteristic of all the plants of *Ligusticum antipodum* I have seen.

On Antipodes Island the plant is also abundant; on the maritime tussock slopes where the tussocks are not so close together, and on the flat tussock meadow, it occurs in such quantity as to add bright-green patches of colour in an equal proportion with the yellow grass or dark fern. It plays an important part as a shelter plant, its leaves spreading out radially, with their surface more or less horizontal, such plants averaging about 78 cm. in diameter and 22 cm. in height. It is found again in the "bog"—patches of very wet soil in the meadow—and here it is very abundant, more so than in the adjacent meadow.

Anatomy (figs. 8*a*, 8*b*, 8*c*).—The leaf is roughly oval in transverse section, with a depression on the upper surface above the main vascular bundle, and a ridge corresponding to it on the lower surface. The cuticle (*cut.*) is strongly developed, being very thick and wrinkled. The upper epidermis (*ep.*) is composed of thick-walled cells, some with very small lumina and highly refractive thick cell-walls. Stomata (*st.*) occur on both surfaces, the opening or stoma being partially overlapped by the projections of the cuticle (fig. 8*c*). Below the epidermis comes a layer of stereom (*sm.*) tissue, sometimes only one cell in thickness, in other places several cells thick and extending right into the chlorophyll tissue towards the vascular bundles. This is also further strengthened with collenchyma (*col.*), which acts as water-storage tissue. The chlorenchyma (*chlor.*) is not differentiated into the ordinary palisade and spongy tissue, but consists of a homogeneous mass of small, somewhat oval-shaped cells arranged more densely on the outer portion of the tissue,

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* Cockayne (1903), p. 282.

but stretching in chains across the central portion, leaving large air-spaces (*a.s.*). The vascular bundles (*v.b.*) are protected by stereom tissue (*sr.*), and are surrounded by an endodermis (*endo.*).

Stilbocarpa polaris, A. Gray.

"Leaves 6 in. to 12 in. broad or more, almost fleshy, bristly on both surfaces, orbicular-reniform, many-lobed, strongly toothed; veins flabellate, principal veins and smaller reticulations divide the leaf into distinctly marked areas made prominent by the depression of the veins; the bristles of the upper surface, which may be ½ in. or more in length, found in these areas; on the under surface they are found on the larger veins, and are more numerous."*

"The large rhizome, measuring ± 8 cm. by ± 7 cm., creeps on the surface of the ground. Usually about six fully developed leaves are given off from an ascending portion of the stem. These leaves are ± 6 cm. broad at the sheathing base, which is furnished with a very large stipule ± 18 cm. long by 10 cm. wide at the apex, its widest part. Such stipules in part enclose the interior bud, against which they are pressed tightly by their concave inner surface, and play a most important part in its protection. The petiole, ± 54 cm. long, is thick, but hollow. The leaf-blade is orbicular-reniform. It is ± 19 cm. in length, measuring from sinus to apex, and ± 29 cm. broad. These leaf-blades are more or less in the form of a funnel, through the lobes of the reniform base being bent inwards, and so convey any water which falls on them to the roots of the plant. The leaves on both surfaces and the petioles are furnished with many pale hairs 10 mm. in length."†

Hab.—This striking plant was described by Hooker (1847) as *Aralia polaris*, following the nomenclature of Hombron and Jacquinot.‡

Lord Auckland Group and Campbell Island: "In the woods and on banks generally near the sea, but often attaining an altitude of 600 ft. to 700 ft., covering large tracts of ground with its bright and shining green foliage."§ "It occurs everywhere at low elevations on these islands, and is of a decidedly antarctic type, extending from Macquarie Island to Antipodes Islands."||

Auckland Islands: "In the *Pleurophyllum* meadow great

* Kirk (1899), p. 215.
† Cockayne (1903), p. 261.
‡ Voy. au Pôle Sud.
§ Hooker (1847), p. 19.
|| Kirk (1891), p. 221.

rounded leaves still form as dense masses of greenery as in summer."*

Campbell Island: "It accompanies *Ligusticum latifolium* down to the stony beach, but not quite so near the water's edge" (p. 270). "In the *Dracophyllum* scrub it follows the many watercourses which cut into the hillside, and grows luxuriantly in the running water" (p. 273). "It is found in the deep gullies cut into the sides of the scrub formation" (p. 274).

Antipodes Islands: Inland tussock slopes. Frequently fern, tussock, and scrub give place to great masses of *Stilbocarpa polaris*, forming dense thickets. "One colony of this remarkable plant measured 11 m. by 3 m., but those met with further on, of which no measurements were taken, were of much larger size" (p. 292).

Anatomy (figs. 9*a*, 9*b*).—The upper epidermal cells (*ep.*) are large, rectangular, and slightly cuticularised, while those of the lower epidermis are much smaller and have no cuticle. Stomata (*st.*) are found under the surface only. The hairs (*h.h.*) are solid multicellular bodies arising below the veins on the under surface, and in the areas between the veins on upper. Below the epidermis is usually a layer of colourless cells with thinner walls, probably water-storage tissue (*st.l.*). The chlorenchyma is differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade (*pal.*) consists of four layers of small oval-shaped cells, closely packed together, and very regularly filled with chlorophyll. Below this comes the first portion of the spongy tissue, which consists of larger, more rectangular, and colourless parenchyma cells, arranged in chains. Then occurs a large air-chamber separating this last layer from the layer of very small rounded cells densely filled with chlorophyll. The two layers are united at certain parts of the leaf where the veins occur. The vascular bundle (*v.b.*) is surrounded by a thick-walled endodermis, and is strengthened on the under surface by a little mass of hypodermal stereom tissue, and also by a further mass of collenchyma. This tissue in some cases contains a certain amount of chlorophyll where it joins the endodermis. The epidermal cells (*ep.*) immediately below the veins are larger than ordinary, and oval, with projecting outer walls.

Coprosma cuneata, Hook. f.

"Leaves yellowish-green when fresh, crowded, mostly fascicled on short arrested branches $\frac{1}{5}$ in. to $\frac{2}{3}$ in. long, $\frac{1}{10}$ in. broad, linear or oblong-obovate, or obovate-lanceolate or cuneate-oblong, retuse subacute or obtuse, patent or recurved, very rigid,

* Cockayne (1903), p. 258.

coriaceous, often shining; midrib deeply sunk above, narrowed at the base, but scarcely petioled; stipules short, broad, fimbriate or ciliate."*

Hab.—This woody plant forms one of the most constant constitutents of the scrub formations on the more exposed portions of the islands.

In Auckland Island it occurs on the peaty soil of the subalpine meadow, creeping close to the ground, and in that way obtaining shelter from the larger tussocks and more erect plants.

On Campbell Island it forms one of the ligneous members of the *Dracophyllum* scrub, the only approach on the island to a forest formation. It is here more luxuriant where it is sheltered from the wind, but still of a prostrate habit. It occurs also at higher elevations in the subalpine meadow and rock formations, still "prostrate" and "stunted."

On Antipodes Island it is found amongst the scrub, on the tussock slopes, and again in the bog formation, creeping close to the ground; "its small leaves in winter are quite brown" (p. 295).

On the rockery this plant is not more than 1 ft. high, but its straggling habit is very evident, while its scraggy branches with their few scattered leaves would easily associate it with a bleak and wind-swept natural home. Its leaves are very small and wedge-shaped, and occur in greater numbers at the ends of the branches. Dr. Cockayne thus describes the bushes: "As for the *Coprosmas*, they consist within of dense masses of bare interlacing twiggy branches. On the periphery alone of such bushes is the actual green part of the plant, and this leafy zone only penetrates into the plant for a distance of 7 cm. at most" (p. 274).

Anatomy (fig. 10).—There is a very distinct and wrinkled cuticle (*cut.*) outside the epidermis on both surfaces of the leaf. The cells of the upper epidermis (*ep.*) are large, thick-walled, and frequently contain oil-globules (*o.g.*). There are no stomata on this surface. The lower epidermal cells are only about one-quarter the size, and they are interrupted frequently by stomata which are accompanied by subsidiary cells (see fig.). The chlorenchyma is differentiated into palisade (*pal.*) and spongy (*sp.*), but the chlorophyll is poorly developed; instead there are numerous oil-globules (*o.g.*) throughout this tissue of the leaf. The palisade (*pal.*) consists of 3–4 layers of cells about four times as long as broad, closely packed together, except at intervals where they appear to have small openings, probably air-canals (*a.c.*). These differ from any air-canals described in *Ligusticum* in that they are not surrounded by an epithelium,

* Kirk (1899), p. 244.

and do not bear any distinct relation to the vascular bundles, as those of *Ligusticum* appear to do. These in *Coprosma* are just intercellular spaces left in the palisade tissue. The spongy tissue (*sp.*) is made up of irregularly shaped cells with numerous small intercellular spaces between them. The vascular bundles (*v.b.*) are surrounded by an endodermal layer (*endo.*) of parenchymatous cells of varying thickness.

There are no pits on the leaves of this species, and no hypodermal water-storage layer, as described for other larger species by Miss Greensill (1902).

Coprosma repens, Hook. f., Fl. Antarc.

" A small glabrous creeping matted species. Bark grey. Branches from 1 in. to 2 ft. in length, sometimes flaccid, densely leafy. Leaves close-set, rarely distant or fascicled, suberect or spreading, $\frac{1}{10}$ in. to $\frac{1}{3}$ in. long, linear-oblong or broadly oblong to linear or broadly obovate, rounded at the tips or subacute, narrowed into very short broad petioles, veinless, very coriaceous, margins thickened. Stipules broad, obtuse, usually glabrous."*

In the leaves of the plant growing on the rockery a midrib was distinctly visible, and on examining a transverse section the presence of several smaller veins was revealed.

Hab.—This plant occurs on Auckland Island in the subalpine meadow, the soil of which is in some places so wet as to deserve the name of bog. Its stems here are described as fleshy.

On Campbell Island it occurs in a much bleaker situation on the subalpine tussock meadow, where there are colder winds and the frosts are longer and more severe than at a lower level. Here its growth is stunted. " Wind is here the determining factor as to whether grass or arborescent growth shall predominate " (p. 278).

On Antipodes Island, in the tussock meadows where there is a badly drained and poorly nourished soil, the *Coprosma* bushes are also stunted in their growth, and this where the soil is of a soft peaty nature, and so moist that " it can be quickly kneaded into the consistency of porridge." In the bog formation, where " water can be readily wrung out of the surface soil," *Coprosma repens* is again found.

The small plant growing on the rockery illustrates strikingly the peripheral position of the leaves. The bare stem, about 2 ft. in length, bends right over and almost buries its leafy terminal portion in the soil, so that I was for some time in danger of overlooking it altogether. Its anatomical structure presents

* Kirk (1899), p. 245.

some slight modifications on that of *Cop. cuneata*, but possesses in common with it a strongly wrinkled cuticle and numerous oil-globules throughout its tissue.

Anatomy (fig. 11).—There is a distinct and wrinkled cuticle (*cut.*) on both surfaces. The cells of the upper epidermis (*ep.*) are large, and contain numerous oil-globules (*o.g.*). Stomata (*st.*) are found only on the lower epidermis (*l.ep.*), the cells of which are much smaller than those of the upper. The chlorenchyma is differentiated into palisade (*pal.*)—two layers of large palisade cells, much larger than those of *Cop. cuneata*, and containing more chlorophyll; the spongy tissue (*sp.*) makes up the greater portion of the leaf, and is more loosely arranged than that of *Cop. cuneata*. Bundles of raphides (*r.*) are arranged in certain of its cells. There is a distinct endodermis (*endo.*) surrounding the vascular bundles (*v.b.*). All the tissues contain a considerable amount of small oil-globules (*o.g.*)

Olearia lyalli, Hook. f.

"Leaves broadly ovate or orbicular-ovate; abruptly acuminate; densely tomentose, newly formed leaves white above and below, the tomentum on the upper surfaces falling away in the first winter. Mature leaves very thick and coriaceous, doubly crenate with short sheathing petioles; on young specimens growing in the shade leaves are much thinner and very large."*

"The under surface is densely clothed with flannelly tomentum quite white in colour. This tomentum is rather more than half the thickness of the leaf-substance proper. The young leaf just when it is unfolded from the bud is white and soft like a piece of flannel, being extremely tomentose on both surfaces."†

Hab.—This tree is extremely local in its distribution. It is not found at all in New Zealand, but occurs only on the Snares, where it is the principal tree on the island. "On Ewing Island, and perhaps to a very limited extent on Auckland Island itself."‡

Snares Island: This tree, by reason of its white-covered leaves, gives a peculiar grey or whitish hue to the foliage. Kirk describes its mode of growth as follows (1891, p. 215): "When growing in level situations it is erect, with open spreading branches; but when growing on slopes exposed to the wind it is often inclined or with a prostrate trunk, the roots partly torn

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* Kirk (1891), p. 216.
† Cockayne (1903), p. 253.
‡ Cockayne (1903), p. 252.

out of the soil, and the branches rooting at the tips give rise to new trunks, which in their turn are brought to the ground and repeat the process."

Auckland Islands; Ewing Island: "Most of them are erect and well-grown, but a few exhibit the inclined position so frequent on the Snares."* Dr. Cockayne considers that although this prostrate habit is frequently caused by the wind, it may become hereditary. The seedlings which were found in great quantities in the interior of the forest, where the air is comparatively still, were found by him to have their stems prostrate on the ground for more than half their length (p. 254). So in these cases the tendency had become hereditary.

There is a plant growing in the shade afforded by a high iron fence on the west side of the laboratory. This plant is quite erect, and shows the characteristic appearance of the leaves. In the older ones the tomentum has fallen off the upper surface, while the younger ones are completely covered and feel "soft as a piece of flannel."

Anatomy (figs. 12*a*, 12*b*).—A cuticle (*cut.*) is developed on the upper epidermis, thick but smooth. The cells of the upper epidermis (*ep.*) are much larger than those of the lower (*l.ep.*), and very thick-walled, in some cases somewhat flattened. In the younger leaves these cells grow out to form a tomentum, also with thick walls. The remains of one or two of these hairs may be seen at *h* in the figure. These hairs fall away the first winter. The lower epidermis (*l.ep.*) is irregular in outline, and the small cells grow out into a thick mass of long woolly hairs (*h.*), chiefly below the veins. These completely protect the projecting stomata (*st.*). The hairs will serve the double purpose of protecting the stomata from the action of the winds, which tend to cause excessive transpiration, and also serve to retain any water which falls on the leaf. Amongst these hairs and also protected by them are found a number of multicellular bodies, probably glandular, the cells of which contain a small quantity of chlorophyll (fig. 12*b*). These can assist the plant by absorbing water held in the spaces between the hairs. The stomata (*st.*) project from the surface, and each guard-cell is accompanied by a subsidiary cell which probably aids in opening and closing the stoma. Underneath the upper epidermis is found a tissue from 2–3 cells thick of very large thick-walled cells, probably collenchymatous water-storage tissue (Pierce). The cells are quite empty, and at intervals above the vascular bundles interrupt the palisade parenchyma, and continue down the whole breadth of the section to the endodermis of the vascular bundle, in some cases pre-

* Kirk (1891), p. 219.

senting a scalariform appearance similar to the thickenings of the scalariform tracheides of ferns. The chlorenchyma is differentiated into palisade (*pal.*) of two layers and spongy (*sp.*) of three or four layers of cells. The palisade cells are very large in comparison with those of the spongy tissue, elongated at right angles to the surface, being about twice as long as broad, with few but large chlorophyll corpuscles. The spongy tissue consists of small irregularly shaped cells, sparingly filled with large corpuscles, and leaving comparatively few air-spaces. These border directly on the lower epidermis. The vascular bundles are found of varying size in a transverse section, but all are surrounded by an endodermis of round cells. The larger ones consist of a dark xylem and a light-coloured phloem, with a band of cells intermediate in colour between the two (fig. 12*a*). Underneath the larger bundles also is a ridge of tissue composed of more or less rounded and thick-walled cells. The cells of the epidermis adjoining them are larger than the other cells of the lower epidermis, and, as I mentioned before, considerably elongated into hair-like outgrowths.

Abrotanella rosulata, Hook. f.

"A small, densely tufted, moss-like plant. Leaves imbricating, patent or recurved, rigid, coriaceous, $\frac{1}{4}$ in. to $\frac{1}{3}$ in. long, narrow, ovate or lanceolate, acute, concave above."*

"It has wiry stems, creeping at first, but finally erect, covered more or less with old dead leaves. The terminal leafy portion of the shoots measures 1·3 cm., and consists of spreading imbricating leaves, the uppermost of which form a stiff, dark-green rosette about 1·3 cm. in diameter, the individual leaves so spreading outwards as to have their upper surface horizontal. The individual leaves are linear or linear-lanceolate, sheathing at the base, which is frequently purplish-rose-coloured, coriaceous, concave on the upper surface."†

Hab.—Kirk mentions it in his account of the Campbell Island flora: "The endemic *A. rosulata* occurred sparingly on exposed rocks, but was not observed below 1,000 ft." ‡ Dr. Cockayne places it amongst the subalpine rock vegetation of Campbell Island, forming "stiff rosettes" on "the face of a precipitous rock facing north-west at an altitude of about 538 m." (p. 282). It may be classed, therefore, as a rock-plant with *Phyllachne clavigera*, *Colobanthus subulatus*, and its relative, *Abrotanella spathulata*, and with them presents certain xerophytic characters in its anatomical structure.

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* Hooker (1864).
† Cockayne (1903), p. 283.
‡ Kirk (1891), p. 223.

Anatomy (fig. 13).—There is first a very thick and wrinkled cuticle (*cut.*) on the upper surface. The epidermal (*ep.*) cells are also thick-walled, and more or less cubical in shape. On the upper surface stomata (*st.*) are present, slightly sunken below the cuticle. On the lower surface, which is not exposed to the sun or wind, there is no cuticle, and the stomata appear on a level with the epidermal cells. At the most convex part of the leaf the epidermal tissue is strengthened by two or three layers of very thick-walled cells, which may represent stereom-supporting tissue. The chlorenchyma is differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade consists of 3–4 layers of the ordinary palisade cells, somewhat small and very closely packed, and densely filled with chlorophyll. Below this comes the spongy tissue, first consisting of a mass of larger rounded cells occupying the centre of the leaf, and below these again come smaller rounded cells bordering on the lower epidermis, and densely filled with chlorophyll. The intermediate larger cells are somewhat scantily supplied with chlorophyll. The vascular bundles (*v.b.*) are regularly arranged in the leaf. In the lower part of the leaf we find five bundles; higher up the two have converged into three, and higher up still only one is found. Resin-passages regularly lined with epithelium are found, usually one above and one below each bundle.

Abrotanella spathulata, Hook. f.

"Leaves narrow, linear-spathulate, ½ in. to 1 in. long, obtuse or acute, rather close-set, spreading, foliaceous."*

Hab.—"Auckland Islands, 1,000 ft. to 2,000 ft.; Campbell Island, 500 ft. to 800 ft."†

I find that Dr. Cockayne has not given any account of this plant except to state, in the list of plants at the end of his paper, that it is found in Auckland and Campbell Islands. He also mentions it (p. 281) as belonging to the subalpine rock flora of Campbell Island. It belongs to the same class of rock-plants, and would be found in Auckland Island on the higher rocky ground. It is growing on the rockery side by side with *A. rosulata.* Its leaves are longer and the rosettes consequently larger than those of *A. rosulata,* and the purplish colour of the lower membranous portion of the leaf is absent in *A. spathulata.* Otherwise the appearance of the two is very similar, and an examination of the anatomy does not reveal any striking differences. There are more vascular bundles and consequently more resin-passages, but in other details the structure is very similar.

* Kirk (1899), p. 330.
† Kirk (1899), p. 331

Anatomy (fig. 14).—In a transverse section of a leaf of this plant were seen small pits or indentations on the upper surface, one of which is given in fig. 14*a*. These pits, or others very similar to them, are found on both surfaces of the two species of *Cotula* next described, but what their significance is I cannot say. They are not there for the protection of the stomata, for the stomata occur on the exposed epidermal surface. In this plant the bordering epidermal cells contained several small oil-globules, which were also found in other cells of epidermis. There is a thick, smooth cuticle (*cut.*) protecting the epidermis on the upper surface. The epidermal cells (*ep.*) are more or less cubical, except those forming the lining to the pits (*a*), which are somewhat elongated. Stomata (*st.*) are found on both surfaces. The chlorenchyma is differentiated into palisade of 4–5 layers of slightly elongated cells, somewhat larger than those of *A. rosulata*, and spongy tissue (*sp.*), consisting of rounded cells similar in size and position to those of *A. rosulata*. The vascular bundles (*v.b.*) are surrounded by a well-marked endoderm, while above and below each bundle is a resin-passage (*c*) lined with epithelium. Another resin-passage is found near each edge of the leaf, so in the sections figured in Plate XXXI there are eight resin-canals and three vascular bundles. Below the midrib is a layer two cells thick of hypodermal collenchyma (*col.*), while the epidermal cells themselves are also strengthened by collenchymatous tissue.

Cotula lanata, Hook. f.

"*Cotula lanata* has pale-green or brown prostrate stems, which creep along the ground or hang down the face of vertical cliffs. The extremities of the stems are ascending, bending upwards and bringing into the light the terminal leaf rosettes, which consist of a few spreading pale-green pinnatifid leaves. The stems are marked at intervals with old leaf-scars, and from some of the nodes roots pass downwards into the rock-crevices, thus firmly anchoring the plant to the substratum. Leaves are fleshy and vary in colour, those innermost and not fully developed being of a darker green than the longer and more external ones. In shape they are obovate, the blades deeply pinnatifid, $\pm$ 15 mm. long by $\pm$ 12 mm. broad, and the segments are toothed on the upper margins [see fig. 15*b*]. Such teeth, $\pm$ 2 mm. long, are bent at an angle, frequently almost at a right angle, to the plane of the leaf, thus making one-third of the assimilating surface vertical or nearly so, while the remaining two-thirds is horizontal. The fleshy, pale-coloured petiole is nearly twice as long as the lamina, and possesses a broad sheathing base $\pm$ 5 mm. long, furnished with a membranous margin. The petiole and midrib are covered, especially in young leaves, with cottony hairs loosely interwoven. The leaves close to the end of the shoot are arranged spirally, but the remainder are brought into two ranks through twisting of the leaf-sheath, the leaf-surface thus becoming horizontal"* (*cf. Epilobium confertifolium*).

Hab.—This plant appears to flourish well near the sea, where it is frequently washed by the salt spray. In the Auckland Group it is found in certain cases trailing over the rocks on the shore just above high-water mark, and therefore "very frequently drenched by the sea-spray," or rooted in the chinks of the vertical rocks with its long stems trailing down the face of the rock. It is also mentioned as occurring in the *Pleurophyllum* meadow with *Cot. propinqua.*

On Campbell Island it is found creeping over the stones of the rocky shore.

Plants inhabiting a maritime region are sometimes spoken of as salt-loving, but this name is a misnomer. Plants thus situated often flourish quite as well, if not better, in a soil free from salt; but in this way they escape competition with other plants which would certainly get the best of them in a richly cultivated soil. They have some particular adaptation which enables them to compete successfully with the adverse conditions which would kill other plants at once. So they flourish where they can, "but at the same time are always tacitly protesting against their environment, for they at once show how much more vigorous they can become when they are grown in a different and more congenial soil."† So this *Cotula lanata* flourishes very well on the rockery right away from sea-spray, but its peculiar and characteristic structures by which it prepares itself to maintain an existence in its natural habitat remain, being hereditary.

The leaves are thick and fleshy, and little pits may be seen covering both surfaces. In the drawing illustrating a transverse section through the leaf the upper surface is more or less flattened, while the lower surface is concave.

Anatomy (figs. 15*a*, 15*b*, 15*c*, 15*d*).—Fig. 15*a* is a section through one of the teeth into which the upper margins of the leaflets are divided. The leaf is seen to be composed chiefly of a large-celled thin-walled parenchyma (*par.*) containing few chlorophyll corpuscles, and leaving frequent air-spaces (*a.s.*), which occupy the centre of the leaf. This is bounded on each surface by a compact tissue, three cells or more in thickness,

* Cockayne (1903), p. 241–2.
† Henslow (1895), p. 34.

of small rounded cells with numerous chlorophyll corpuscles. This answers to the palisade tissue of other dorsi-ventral leaves, and is marked *pal.* These teeth are bent up at right angles, so that both sides are equally illuminated, hence the isolateral structure of the leaf. Another peculiarity is the presence of numerous pits or depressions, probably glandular, which are scattered over the leaf. These, as seen in fig. 15*b*, are walled in by epidermal cells much longer than the ordinary cubical ones, and at the base bounded by one or two smaller cubical cells. There is a thin cuticle (*cut.*) developed. The vascular bundle is surrounded by a well-marked endodermis (*endo.*), with walls considerably thickened. This is again surrounded by a layer of colourless parenchyma (*p.s.*) similar to the central water-storing tissue, the parenchyma sheath.

Cotula propinqua, Hook. f.

This plant differs from *Cotula lanata* in the appearance of the rosettes of leaves: they are much more open and spreading. The leaves themselves are larger, as will be seen by comparing figs. 15*d* and 16*b*. The teeth into which the blade is divided do not overlap as in the case of *Cot. lanata*, and so the leaf appears flatter.

In the anatomical structure (figs. 16*a*, 16*b*, 16*c*) there are one or two points of difference. The cells of the palisade tissue (*pal.*) are larger in *Cot. propinqua*, and the corpuscles are also larger. The internal spongy tissue (*sp.*) is not so open, and the constituent cells are smaller, than in *Cot. lanata*. The stomata (*st.*) (fig. 16*c*) are well developed; the guard-cells are kidney-shaped, and contain a very regular row of chlorophyll corpuscles, giving a beaded appearance.

Pleurophyllum speciosum, Hook. f., Fl. Antarc.

"Leaves all radical, 6 in. to 18 in. long, 5 in. to 10 in. broad, usually appressed to the ground, forming a huge rosette, broadly ovate or obovate or unequally rhomboid, rounded at the apex or shortly acuminate, thick when fresh, with 15–20 longitudinal ridges, loosely tomentose below, villous or setose above, the bristles being intermixed with rather long moniliform hairs."*

Hab.—"Lord Auckland Group and Campbell Island; chiefly found upon wet banks and in marshes near the sea, but also ascending to the tops of mountains in a stunted form."†

On the Auckland Islands Kirk (1891, p. 220) describes the plant as covering acres, giving a unique effect, approaching the

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* Kirk (1899), p. 277.

† Hooker (1847), vol. i, p. 31.

magnificent. "As the traveller walks amongst them his feet crash through the horizontal leaves as though he were walking on thin ice." On Campbell Island he notices that the plant here differs from that of the Auckland Islands: the leaves are larger, rather narrower, and more or less erect; they are invariably clothed with jointed or moniliform hairs mixed with straight tomentum, a character which is rare or absent from the Auckland Island form. "It is noteworthy that these differences, although of a trivial character, have proved constant under cultivation during ten years."*

"In winter the huge leaves are altogether wanting and the rosettes are small and bright-green in colour, the leaves pressed closely against the ground. These rosettes vary considerably in size according to their position with regard to wind and light, those of shady gullies being much larger than those of the hill-side."†

On Campbell Island the plant is found where the ground is fairly wet, "its leaves larger and less decayed than in the meadow formation of Auckland Island" (p. 273). It is also found at higher levels in the tussock meadow, and still higher in the subalpine tussock, where the ground presents all the conditions necessary for a true bog formation.

The habit of the plant in forming these huge rosettes of leaves tightly pressed on the ground is of distinct advantage to it in resisting the severe winds which sweep over these open formations where the plant occurs. The leaves are so situated as to form a kind of cup in the centre. During rain this cup quickly fills with water, which soaks rapidly through the leaf-bases, bringing fresh rain-water to the roots. The leaves also become thoroughly wetted, their numerous hairs helping to hold the moisture, and it is probable that these also assist in the supply of pure water through their power of absorbing such, as suggested by Diels.‡

Anatomy (figs. 17*a*, 17*b*).—The plant growing on the rockery is not thriving very well, the rosette being very small, just 6 in. in diameter, and the largest leaves only 3 in. long. I did not venture, therefore, to injure it in any way by cutting at the leaves, and examined only a portion of the leaf in spirit. The chlorophyll is therefore undistinguishable. Fig. 17*a* is taken through one of the prominent ribs on the under surface, and shows the position and structure of the vascular bundle (*v.b.*). Fig. 17*b* is a section through the mesophyll tissue

* Kirk (1891), p. 224.
† Cockayne (1903), p. 258.
‡ Cockayne (1903), p. 259.

between two ribs, and shows the arrangement of this portion of the leaf. There is no cuticle, but numerous jointed hairs (*h*) are developed from the epidermal cells of both surfaces. The upper epidermis (*ep.*) consists of regular thin-walled rectangular cells, somewhat larger than those of the lower epidermis (*l.ep.*). Stomata (*st.*) are found only on the lower surface. Beneath the upper epidermis are arranged two rows of large colourless cells, acting as water-storage tissue (*st.l.*), and below these again come the chlorophyll-containing cells. They can hardly be said to be differentiated into palisade and spongy tissue. All the cells are of a fairly uniform size, being more or less cubical. Those just below the storage tissue are arranged compactly in two layers; the rest, about eight layers, are arranged more or less in chains, the ends of which adjoin the lower epidermis, thus leaving large air-spaces (*a.s.*) on the lower side of the leaf. The ribs of the leaf are made up of a mass of rounded collenchyma cells of varying size. On the lower surface the epidermal cells (*l.ep.*) are small in comparison, and thick-walled, giving rise to numerous hairs (*h.*), and just above this layer is another of larger cubical thin-walled parenchyma cells (*par.*). The vascular bundle (*v.b.*) is surrounded by a thick-walled endodermis (*endo.*). The xylem (*xy.*) is very strongly developed, while above it comes a tissue resembling the *phloem* (*ph.*) tissue below.

Senecio antipoda, Kirk.

"Branches spreading from base, very stout, grooved, $\frac{1}{3}$ in. to $\frac{1}{2}$ in. in diameter, fistulose, glabrous except peduncles and young leaves, mealy-tomentose beneath. Radical leaves apparently narrowed into a petiole; upper sessile by a broad auriculate base, membranous, sparingly and irregularly pinnatifid or partite, 2 in. to 5 in. long, 1 in. to 3 in. broad; segments toothed, lobed, or almost pinnatifid, acute."*

"The upper surface of the leaf is green and almost glabrous in adult leaves, but the under surface is more or less tomentose with loose cobwebby hairs, the tomentum being much more abundant in young than in old leaves. The margins are recurved, and on the under surface of the leaf is a prominent midrib which gradually broadens towards the base. The tomentum plays an important part in protecting the bud in winter."†

"*Senecio antipoda* much more resembles the common European groundsel in outward appearance than do any others of the herbaceous section of this genus in New Zealand" (p. 293).

* Kirk (1899).
† Cockayne (1903), p. 294.

Hab.—This interesting plant occurs only on Antipodes Island, and only in a certain part of that island. It is the dominant member of an association found on "the bare ground manured by the giant petrel (*Ossifraga gigantea*)" (p. 293). In this respect it resembles the endemic *Cotula featherstonii* of Chatham Island, which is found growing near the holes of the mutton-birds. With this *Senecio* are associated "very thick masses of *Acæna* frequently mixed with *Pteris incisa*." With regard to this fact that we have an endemic species arising in two instances under similar conditions, Dr. Cockayne expresses himself thus: "I do not see why rich heavily manured soil should not be just as much a factor in determining the life-form of a plant as illumination, moisture in the air, wind, or any other ecological factor; and to find two plants each of distinctly luxuriant growth growing under very similar conditions is suggestive, to say the least" (p. 293).

Dr. Cockayne brought a plant from the islands and it was planted on the rockery, but it has since died, and shows no signs of sprouting again. There were only two or three green leaves left on the plant when I examined the rockery at the beginning of this year, and I was advised to examine them at once if I wished to do so at all, and therefore took the earliest opportunity of doing so before the plant died.

Anatomy (fig. 18).—This section includes the midrib, causing a marked prominence on the under side of the leaf and marked by a deep depression on the upper side. There is a very thin cuticle, if any at all, but the epidermal cells are provided with greatly thickened cell-walls. Those of the upper epidermis (*ep.*) are much larger than those of the lower. In the young leaf which was examined the woolly tomentum (*h.h.*) was present on the lower surface and protected the stomata (*st.*), which occur only on this surface in the areas between the veins. The guard-cells contain several large chlorophyll corpuscles. The chlorenchyma is arranged as in any typical dorsi-ventral leaf. The palisade tissue (*pal.*) is two layers in thickness, composed of typical palisade cells with chlorophyll corpuscles arranged on the side walls. This passes into the open spongy tissue (*sp.*) which comprises the greater thickness of the leaf. A mass of thin-walled rounded parenchyma cells occupies the keel of the leaf, the larger cells near the main vascular bundle (*v.b.*) and smaller cells towards the epidermis, which here consists of a single layer of small thick-walled cells. In the phloem (*ph.*) of the bundle figured is a canal (*c.*) lined with epithelium (*b.*). The xylem (*xy.*) consists of rather large vessels arranged in chains.

Phyllachne clavigera (F. Muell.), Hook. f.

"Large green cushions, some of great size, the extremities of the shoots rooting in the decayed leaves now turned into peat, which make up the chief bulk of the cushions. Each main shoot branches near its extremity, giving off several short shoots 1·5 cm. in length, the upper 6 mm. of which are densely clothed with very small imbricating green leaves. These final shoots are all pressed tightly together, and make apparently a solid convex mass. The leaves are very thick, coriaceous, expanded at the base, convex on the under (outer) surface, but slightly concave on the lower half of the upper (inner) surface, but flat on its upper half. They are not quite erect, but the globose tips point slightly outwards."*

This plant was described by Hooker (1847) as *Forstera clavigera*, Hook. f., but its claim to be included in the genus *Phyllachne* has since been established.

Hab.—"Lord Auckland Group and Campbell Island: on the mountains in turfy and boggy places; very common."†

The semi-bog of the subalpine meadow of Auckland Island may be recognised "by the presence of the large, round, bright-green, dense cushions of *Phyllachne clavigera*."‡

On Campbell Island it forms "large, bright-green, hard cushions" where the ground is wettest in the subalpine tussock meadow, and also among the subalpine rocks under similar conditions.

This plant is a "bog xerophyte of the typical form of many other antarctic cushion plants" (p. 265), which reaches its climax in the vegetable-sheep (*Raoulia mammillaris*) of New Zealand.

Anatomy (fig. 19).—This section is taken through the globose tip of a leaf, and is more or less hemispherical. The flatter surface represents the inner side of the leaf, and the convex the outer side. There is a distinct thick and wrinkled cuticle (*cut.*) surrounding the leaf. Underneath is the epidermis (*ep.*) of thick walls and rather large cells; stomata (*st.*) occur on any part of the epidermis. The chlorenchyma (*chlor.*) consists of a homogeneous mass of rounded cells, which occupy the entire section of the leaf. The outer portion is perhaps more densely filled with chlorophyll, and the cells are more closely packed, than in the central portion. Sometimes the cells appear to be arranged in chains, which, arising from the epidermal cells, converge towards the centre of the leaf where lies the vascular

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* Cockayne (1903), p. 280.
† Hooker (1847), vol. i, p. 38.
‡ Cockayne (1903), p. 265.

bundle (*v.b.*). The vascular bundle is surrounded more or less completely with a ring of large colourless parenchyma cells (*par.*).

Pratia arenaria, Hook. f.

In Hooker's Handbook this plant is described as *Pratia angulata*, var. *arenaria*. The leaves are orbicular, sinuate-toothed, shortly petioled, and membranous.*

Hab.—"Lord Auckland Group: creeping over the open sandy shores of Enderby's Inlet, Rendezvous Harbour; Lieutenant H. Oakley."†

This plant occurs associated with *Epilobium confertifolium* on the shady side of the gullies between the sand-dunes on Enderby Island.‡ It is also found in the tussock meadow of Antipodes Island.

Anatomy (fig. 20).—The leaf I examined was a young one, but could be easily identified as *Pratia* by the angular margin. The cells of the epidermis (*ep.*) were thin-walled, except beneath the vascular bundle, where the walls were considerably thickened (*l.ep.*). There was no cuticle developed, and stomata (*st.*) occurred on both surfaces. The chlorenchyma was differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade tissue was just one cell in thickness, and the cells were the regular palisade form with chlorophyll corpuscles arranged on the side walls. The rest of the chlorenchyma is composed of spongy tissue (*sp.*), large thin-walled cells, not so densely filled with chlorophyll and not very loosely arranged. Underneath the vascular bundle is a mass of smaller-celled colourless tissue with thicker walls. The bundle (*v.b.*) is surrounded by a well-marked endodermis (*endo.*).

The spongy tissue will most probably act as water-storage tissue as well as the thicker-walled tissue beneath the bundle, a necessary modification for a maritime plant such as this.

Gentiana cerina, form v concinna, Kirk.

"Leaves very thick, coriaceous, obovate or spathulate-oblong, $\frac{2}{3}$ in. to $1\frac{1}{2}$ in. long; radical and cauline similar, 3-nerved"; form v *concinna*, "long, coriaceous, obtuse, often recurved." "A most beautiful plant; remarkable for the thick, trailing, leafy stems, bright-green, shining, succulent foliage."§

* Hooker (1867), p. 172.
† Hooker (1847), vol. i, p. 41.
‡ Cockayne (1903), p. 238.
§ Hooker (1867), p. 191.

"In winter it has rather dense rosettes, crowded together, of dark-green imbricating leaves, the four or five outer leaves much larger than those crowded internally. In spring the rosettes open out, and the new branches spread out radially, with their tips ascending."*

Hab.—"Lord Auckland Group: near the sea on rocky islets in Rendezvous Harbour."†

In the *Pleurophyllum* meadow of Auckland Island "are grass-like tufts of *Scirpus aucklandicus* and the silvery-leaved *Helichrysum prostratum*, and very frequently associated with these are the shining green winter rosettes of *Gentiana cerina*."‡

There are several rosettes of this plant on the rockery; it has grown and spread since it was planted there last year.

Anatomy (fig. 21).—The leaf I examined was very thick and coriaceous, with recurved margins. There is a more or less well-defined smooth cuticle (*cut.*) on the upper surface. The upper epidermal cells (*ep.*) are thick-walled, and slightly rectangular in shape. Those of the lower epidermis (*l.ep.*) are smaller, with thinner walls, no cuticle, but interrupted by numerous stomata (*st.*). The chlorenchyma is differentiated into palisade tissue (*pal.*)—consisting of oval cells in four layers and densely filled with chlorophyll—and spongy tissue, which makes up the greater thickness of the leaf, being about double that of the palisade. This tissue is loosely arranged, leaving numerous air-spaces (*a.s.*), and is not so densely filled with chlorophyll. The vascular bundle (*v.b.*) is surrounded by an endodermis (*endo.*) of colourless cells, surrounded by the larger chlorophyll containing cells of the mesophyll. The recurved margins of the leaf, together with the rosette formation, serve to protect the stomata on the under surface, and so check the rate of transpiration of the leaves.

Myosotis capitata, Hook. f.

"Leaves radical, linear, obovate or lanceolate, obtuse, 2 in. to 4 in. long, narrowed into broad petioles, hispid-pilose on both surfaces; cauline linear, oblong or spathulate, sessile."§

"In winter it presents semi-rosettes of rather thick, soft, dark-green leaves, covered on the upper surface with bristly white hairs. The stems are prostrate, but with the extremities ascending and forming roundish tufts ± 16 cm. in diameter, and 6 cm. from the surface of the ground. The leaves are

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* Cockayne (1903), p. 263.
† Hooker (1847), vol. i, p. 54.
‡ Cockayne (1903), p. 259.
§ Hooker (1864), p. 194.

semipatent, and frequently recurved at their extremities, and dense enough for one rosette to touch the next."*

Hab.—Auckland Island: "On gravelly banks near the margins of woods close to high-water mark."†

In the *Pleurophyllum* meadow formation of Auckland Island (Cockayne).

Anatomy (figs. 22*a*, 22*b*).—There is no cuticle, but the epidermal cells (*ep.*) are protected by the very numerous hairs (*h.h.*) which are found thickly covering both surfaces, more especially the upper, which is most exposed. These hairs are unicellular outgrowths of the epidermal cells. The upper epidermis (*ep.*) consists of regular rather thick-walled cells with no stomata; in the lower epidermis (*l.ep.*) the cells are smaller, thin-walled, and interrupted by very numerous stomata (*st.*). The chlorenchyma (*chlor.*) forms a regular palisade tissue (*pal.*), three cells in thickness, densely filled with chlorophyll. The spongy tissue (*sp.*) occupies the greater thickness of the leaf, and is composed of irregularly shaped cells, very loosely arranged, and so leaving numerous air-spaces. The vascular bundles (*v.b.*) are surrounded by the endodermis (*endo.*), and further by a colourless parenchyma sheath.

Veronica benthami, Hook. f.

"Leaves crowded towards ends of branches, sessile, ½ in. to 1½ in. long, linear or obovate-oblong, obtuse, margin with a few deep serratures and edged with down, very coriaceous, flat, veinless; opposite pairs connate at the very base."‡

"Leaves are thick, rather soft, narrow obovate-oblong in shape, dark-green; with regard to the light, the surfaces of the lower and larger leaves are horizontal and frequently arch downwards somewhat. The structure is that of a typical dorsi-ventral leaf. Nearer the apex of the shoot the leaves are smaller than those below, broader in proportion to their length, and loosely imbricating."§

Hab.—"Small dwarf plant with deep glossy green foliage; near the sea."||

This plant is confined to the Auckland and Campbell Islands. On Campbell Island it is found growing through bushes of *Coprosma* or amongst the tussock, with its "rather straggling naked stems marked with many leaf-scars, but quite green above."§ It appears again in the subalpine rock formation, in

* Cockayne (1903), p. 263.
† Hooker (1847), vol. i, p. 56.
‡ Hooker (1867), p. 214.
§ Cockayne (1903), p. 277.
|| Kirk (1891), p. 221.

those hollows between the rocks which afford plenty of shade and moisture and which are large enough for peat to have collected in abundance. In these same hollows occurs also the *Ranunculus pinguis* described above.

Anatomy (fig. 23).—There is a smooth thickened cuticle (*cut.*) on both surfaces, interrupted on the lower side by numerous stomata (*st.*), which project slightly. The epidermal cells (*ep.*) are more or less cubical, with slightly thickened walls, the same size on both upper and lower surface. Just above the one vein is a depression on the upper surface, and this is lined by epidermal cells somewhat smaller than the rest, with slightly thicker cell-walls. The hairs (*h.h.*) forming the tomentum at the edges of the leaf arise in the epidermal cells: they are short and thin-walled. The chlorenchyma is differentiated into palisade (*pal.*) and spongy (*sp.*). The palisade tissue consists of a layer three cells thick of rectangular cells densely filled with chlorophyll. This passes gradually into the spongy tissue, composed of irregularly shaped cells with numerous air-spaces (*a.s.*), making up the greater part of the tissue of the leaf. There is only one vascular bundle (*v.b.*) in the centre of the leaf, which is situated beneath a depression on the upper surface. (This is probably what is meant by describing the leaf as "veinless.") The bundle is surrounded by a well-marked endodermis (*endo.*).

Plantago, sp.

There seems to be some doubt as to the real affinities of this species. It is found only on Ewing Island of the Lord Auckland Group, growing on the coastal rocks. Its leaves are arranged in rosettes. The upper portion of each leaf is toothed. In the small leaves I examined there were only two teeth, one on each side (fig. 24*c*). The lower portion is membranous and frequently coloured at the base with red colouring-matter. It grows with leaves flattened close to the rock. Dr. Cockayne states (p. 239) that this is the species referred to by Hooker (Fl. Antarc.) as *P. carnosa*, but that he afterwards classed it with the species *P. brownii*. In Dr. Cockayne's opinion, however, this plant bears "no resemblance whatever to the plant known as *P. brownii* in the Southern Alps. It much more resembles a species of *Plantago* very common in coastal situations in the neighbourhood of Foveaux Strait, which is probably *P. hamiltonii*, Kirk. The Auckland Island species certainly seems to me distinct from any New Zealand species" (p. 323).

There is a specimen of this plant growing on the rockery. The snow and frosts last winter destroyed most of the older and larger leaves, but it is now recovering and sending up a small rosette of green leaves through the old decayed ones, while smaller rosettes are springing up all round. I have not been able to examine the plant with which it has been identified, but will merely give an account as fully as possible of its anatomical structure.

Anatomy (figs. 24*a*, 24*b*, 24*c*).—A transverse section through the leaf shows a depression on the upper surface above the midrib, and a corresponding protuberance on the lower surface. Stereom (*sm.*) is developed in small amounts at the edges of the leaf and above the lower epidermis opposite the midrib. The cuticle (*cut.*) on the upper surface is smooth and thick, and the epidermal cells (*ep.*) of the upper surface have also greatly thickened walls. The lower epidermis (*l.ep.*) is made up of much thinner-walled and smaller cells. This surface of the leaf is very irregular. Peculiar hairs (*h.*) are developed on the surface. Each hair (fig. 24*b*) arises from an epidermal cell, and by division forms a stalk of two cells and an upper portion of elongated cells. These hairs are probably glandular. Stomata (*st.*) occur on both surfaces, but are most numerous on the lower surface. The chlorenchyma (*chlor.*) consists of a palisade tissue (*pal.*) composed of 5–6 layers of large oval-shaped cells with chloroplasts along the side walls, and a spongy tissue (*sp.*) closely arranged and consisting of only 3–4 layers. The cells are rounded, and contain few chlorophyll corpuscles. There is a definite and thick-walled endodermis (*endo.*) surrounding the vascular bundle (*v.b.*). There is a strong and unusual development of palisade tissue, which is a modification to intercept heat and light rays.

Astelia linearis, var. subulata.

"Growing in patches, the short stiff vertical green portions of the leaf rising above the ground for about 11 mm. This plant spreads into large colonies by means of its long wiry stems, which creep just beneath the surface of the ground. These stems are covered thickly with old decayed leaf-sheaths, and with these and the roots form extremely dense mats 3 cm. or more in length. . . . Just before issuing from the ground the stem branches into two or three leafy shoots, each furnished with 2–3 green leaves. Such leafy shoots, being quite close, form a rather dense turf. The leaves are ± 2·1 cm. long, and consist of a pale-coloured sheathing base, which is rather longer than the vertical or semi-vertical shining green subulate lamina. There are a few hairs on the sheath, and occasionally at the base of the lamina, otherwise the green portion of the leaf is quite glabrous."*

* Cockayne (1903), p. 266.

This plant, as Dr. Cockayne points out, differs very considerably from the type, *Astelia linearis*, which Hooker (1867) describes as follows: "Leaves spreading, 1 in. to 6 in. long, narrow, linear, acuminate, keeled, margins recurved, silky and villous at the base" (p. 284); and Dr. Cockayne further adds, "that midrib and edge of leaf are covered with adpressed brown chaffy hairs" (p. 266).

Hab.—It occurs on both Auckland and Campbell Islands, in semi-bog formations.

Anatomy (figs. 25*a*, 25*b*).—The leaves are linear, glabrous, solid and cylindrical for the greater part of their length, but split down near the base along the line of colourless parenchyma cells. Fig. 25*a* is a section through the upper solid portion, while fig. 25*b*, which is much larger in proportion, is through the lower crescent-shaped portion of the leaf. The colourless parenchyma is on the upper surface; the leaves are here represented upside down.

Fig. 25*a*: A cuticle (*cut.*) may be distinguished above the epidermal cells, frequently interrupted by stomata (*st.*). The epidermal cells are more or less rounded or cubical in shape. The chlorenchyma (*chlor.*) is not differentiated, but consists of a mass of rounded cells densely filled with chlorophyll except on the upper surface of the leaf, where it is interrupted by a wedge-shaped mass of colourless thin-walled parenchyma cells, which probably acts as water-storage tissue. The number of vascular bundles (*v.b.*) varies. There may be one, two, or three at different heights in the leaf. The bundle is surrounded by a well-defined endodermis (*endo.*).

Fig. 25*b* differs in the position of the colourless parenchyma tissue (*par.*), which here forms a layer two cells in thickness along the greater part of the upper concave surface of the leaf. There are always three bundles in this region. In both cases raphides are present in certain of the chlorophyll-bearing cells, and anthocyanin is sometimes found in the epidermal cells.

Luzula crinita, Hook. f.

"Leaves flat and grass-like, with long white hairs on the margins and sheaths towards the base, $\frac{1}{12}$ in. to $\frac{1}{6}$ in. broad."*

Hab.—"Lord Auckland Group and Campbell Island: in the former locality it is found only near the tops of the hills, at an altitude of 1,200 ft. to 1,400 ft.; more abundant in the latter, from the sea to an altitude of 1,200 ft."†

It is found on most of the Southern Islands—Lord Auck-

* Hooker (1867), p. 293.

† Hooker (1847), vol. i, p. 84.

land Group, Campbell Island, Antipodes Island, and Macquarie Island. It occurs at the higher elevations, away from the sea and amongst the tussock formations.

Anatomy (fig. 26).—There is a very thick cuticle (*cut.*) on both upper and lower epidermis (*ep.*). The cells on the upper surface are very large indeed, their longer axes being at right angles to the surface of the leaf and their transverse walls thin; these cells are equal to any four of the cells of the palisade parenchyma. The cells of the lower epidermis are much smaller and cubical. It is on this surface that the stomata (*st.*) occur in rows between the veins. There are also present multicellular hairs (*h.h.*) attached to the stereom tissue at the edge of the leaf. Stereom tissue occurs at the edges of the leaf, here consisting of cells with thick brown walls. It is also found on the upper and lower surface of each vascular bundle, partially enclosing them. The chlorenchyma (*chlor.*) consists of an undifferentiated mass of small rounded cells arranged along the epidermis and round the vascular bundles, but leaving numerous large air-spaces in the centre of the leaf. The vascular bundles (*v.b.*) occur at different intervals in the chlorenchyma tissue protected by a mass of stereom tissue. There is no well-defined endodermis present. The stereom tissue is developed to give mechanical support to the more delicate tissues against the action of the wind, and the large-celled epidermis acts as water-storage tissue

Scirpus aucklandicus (Hook. f.), Boeck.

This little plant is very widely distributed in the Southern Islands. It forms small soft green tufts measuring about 2 in., and is found growing in the crevices of the coastal rocks on Auckland Island where there is plenty of moisture. It is found in a similar position in Antipodes Island, here forming a dense mass which occupies an area of 1·35 m. by 60 cm., and measuring about 15 cm. deep.

The culms are a light-brown, and membranous, while the leaves arise in tufts (fig. 27*b*). They are roughly oval in outline in transverse section.

Anatomy (figs. 27*a*, 27*b*).—There is a thick-walled epidermis (*ep.*) of rounded cells surrounding the leaf, interrupted at regular intervals by small mass of stereom tissue (*sm.*) and numerous stomata (*st.*). The chlorenchyma (*chlor.*) is undifferentiated, and consists of a mass of small rounded cells in which are imbedded three vascular bundles (*v.b.*). Two large air-cavities (*a.c.*) occur in the central tissue, separated by a band of chlorenchyma only one or two cells thick. These air-cavities are a special modification frequently met with in swampy regions where the soil is not sufficiently aerated.

Carex trifida, Cav.

A very large tall robust leafy sedge, 3 ft. to 6 ft. high ; culms stout, obtusely 3–9-onous, leafy, smooth. Leaves very large and long, ½ in. broad or more, flat, keeled, striate ; margins scabrid. Is much the largest New Zealand species.*

Hab.—This plant is common in New Zealand and in all the Southern Islands except Macquarie and Bounty Islands. In the islands it is a common constituent of swampy ground, taking the place of the tussock-grass. It grows in immense tussocks. The leaf is conduplicate, with a prominent keel on the outer surface.

Anatomy (fig. 28).—The upper epidermis (*ep.*) is composed of large cells with cuticularized outer walls, slightly convex. The cells of the lower epidermis (*l.ep.*) are small, but still thick-walled, and interrupted by numerous stomata (*st.*). Masses of stereom tissue (*sm.*) occur above the smaller vascular bundles, and below the main one situated in the keel of the leaf. Above this main bundle is a mass of large-celled parenchyma, a single layer of which extends below on either side the upper epidermis to the first vascular bundle. The chlorenchyma (*chlor.*) is not differentiated, but consists of a mass of small rounded cells arranged in two layers adjoining each epidermis, leaving between large air-cavities which are separated by strands of tissue surrounding the vascular bundles. Each bundle (*v.b.*) is surrounded by a more or less well-defined endodermis (*endo.*). It occurs near the lower surface of the leaf, and the space between it and the upper epidermis is filled up with a mass of round thick-walled stereom tissue.

Poa foliosa, Hook. f. **Festuca foliosa**, Fl. N.Z., i, 308.

"Culms stout, tufted, tall or short, 1 ft. to 3 ft. high. Leaves flat, glabrous, coriaceous, shorter or longer than culms, $\frac{1}{12}$ in. to ¼ in. broad ; ligule short, membranous, sheaths compressed."

Hab.—This is found on all the islands, excepting of course the Bounty Islands, on which no vegetation occurs except a species of *Durvillæa* attached to the rocks, and on the rocks a species of alga. It forms broad zones of tussock in the different formations, and frequently attains a considerable size.

Anatomy (figs. 29*a*, 29*b*, 29*c*).—The leaf is hinged, and folds over on the central ridge at *a*, *a*. The ordinary upper epidermal cells (*ep.*) are rectangular, with the long axis vertical to the surface, and the outer wall projects into small papillæ with thickened outer walls (*cf. Acæna*). (See fig. 29*b*.) The epider-

* Hooker (1867), p. 316.

mal cells occurring at the hinges *a*, *a*, are very large, with the long axis vertical to the surface, some wedge-shaped; their outer walls are just slightly convex. Above the masses of stereom tissue which occur at regular intervals on the upper surface the epidermal cells are much smaller and flattened, and the walls also do not project. It is on this upper surface, which is also the inner surface when the leaf folds over, that the stomata (*st.*) occur, partially protected by the papillæ. Each guard-cell is accompanied by a subsidiary cell (*sb.*), which assists in opening and closing the stoma (fig. 29*b*). The lower epidermis is composed of very thick-walled cells, with cuticularized walls, generally cubical in shape, those beneath the masses of the stereom tissue being much smaller, but still cubical. Stereom (*sm.*) occurs in various parts of the leaf as strengthening tissue against the effects of the wind. It is found above and below each vascular bundle (*v.b.*). It forms the little ridge projecting above the main vascular bundle on the upper or inner side of the leaf (sm^1), and also a larger mass of it forms the keel-like projection on the lower surface (*sm.*).

At *a* and *a* on either side of the central mass of tissue the tissue between the large upper epidermal cells, which probably act as hinges, and the lower epidermal cells is made up of a mass of thick-walled colourless cells (*col.*). The rest of the leaf consists of chlorenchyma (*chlor.*), small rounded cells densely filled with protoplasm. A well-defined very thick-walled endodermis surrounds each vascular bundle (fig. 29*c*). The xylem (*xy.*) of the bundle shows well-developed and thick-walled xylem vessels on the upper surface.

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List of Plants examined, arranged in their Orders.

Ranunculaceæ.

Ranunculus pinguis, Hook. f.
,, *subscaposus*, Hook. f.
,, *aucklandicus*, A. Gray.

Caryophyllaceæ.

Colobanthus subulatus, Hook. f.

Rosaceæ.

Acæna sanguisorbæ, var. *antarctica*, Cockayne.

Onagrareæ.

Epilobium confertifolium, Hook. f.

Umbelliferæ.

Ligusticum latifolium, Hook. f.
,, *antipodum*, Hook. f.

Araliaceæ.

Stilbocarpa polaris, A. Gray.

Rubiaceæ.

Coprosma cuneata, Hook. f.
,, *repens*, Hook. f.

Compositæ.

Olearia lyallii, Hook. f.
Abrotanella rosulata, Hook. f.
,, *spathulata*, Hook. f.
Cotula lanata, Hook. f.
,, *propinqua*, Hook. f.
Pleurophyllum speciosum, Hook. f.
Senecio antipoda, Kirk.

Stylidiaceæ.

Phyllachne clavigera (F. Mueller), Hook. f.

Campanulaceæ.

Pratia arenaria, Hook. f.

Gentianaceæ.

Gentiana cerina, var. *concinna*, Kirk.

Boraginaceæ.

Myosotis capitata, Hook. f.

Scrophulariaceæ.

Veronica benthami, Hook. f.

Plantaginaceæ.

Plantago sp. (*brownii ?*).

Liliaceæ.

Astelia linearis subulata.

Juncaceæ.

Luzula crinita, Hook. f.

Cyperaceæ.

Scirpus aucklandicus (Hook. f.), Boeck.
Carex trifida, Cav.

Graminaceæ.

Poa foliosa, Hook. f.

EXPLANATION OF PLATES XXVIII TO XXXVII.

PLATE XXVIII.

Fig. 1*a*. Transverse section of leaf of *Ranunculus pinguis*; × 44.
Fig. 1*b*. Transverse section showing stoma (*st.*) and guard-cells (*g.c.*).
Fig. 2*a*. Transverse section of leaf of *Ran. subscaposus*; × 44.
Fig. 2*b*. Surface section of epidermis; × 44.
Fig. 2*c*. Leaf of same.
Fig. 3. Transverse section of leaf of *Ran. aucklandicus*; × 44.
Fig. 4*a*. Transverse section of *Colobanthus subulatus*; × 44.
Fig. 4*b*. Plant of same; half natural size.

PLATE XXIX.

Fig. 5*a*. Leaf of *Acæna sanguisorbæ antarctica*.
Fig. 5*b*. Leaf of var. *pilosa*; half natural size.
Fig. 5*c*. Transverse section, leaf of *Acæna sanguisorbæ antarctica*; × 44.
Fig. 5*d*. Transverse section, leaf of *Acæna sanguisorbæ pilosa*; × 44.
Fig. 5*e*. Transverse section through lower epidermis of *a*; × 65.
Fig. 6*a*. Transverse section of *Epilobium confertifolium*; × 23.
Fig. 6*b*. Shoot of same.
Fig. 7. Transverse section, leaf of *Ligusticum latifolium*; × 23.

PLATE XXX.

Fig. 8*a*. Transverse section, leaf of *Ligusticum antipodum*; × 23.
Fig. 8*b*. Section through resin-canal (*c.*); × 65.
Fig. 8*c*. Section through a stoma; × 65.
Fig. 9*a*. Transverse section, leaf of *Stilbocarpa polaris*; × 15.
Fig. 9*b*. Section showing hair; × 15.

PLATE XXXI.

Fig. 10. Transverse section, leaf of *Coprosma cuneata*; × 23.
Fig. 11. Transverse section, leaf of *Coprosma repens*; × 23.
Fig. 12*a*. Transverse section, leaf of *Olearia lyallii*; × 23.
Fig. 12*b*. Transverse section, showing hairs; *g.h.*, glandular hair; × 65.
Fig. 13. Transverse section, leaf of *Abrotanella rosulata*; × 44.

PLATE XXXII.

Fig. 14. Transverse section, leaf of *Abrotanella spathulata*; × 44.
Fig. 15*a*. Transverse section, leaf of *Cotula lanata*; × 44.
Fig. 15*b*. Section through pit; × 65.
Fig. 15*c*. Section through vascular bundle to show endodermis; × 65.
Fig. 15*d*. Leaf of *Cot. lanata*; half natural size.

Fig. 16*a*. Transverse section, leaf of *Cotula propinqua*; × 44.
Fig. 16*b*. Leaf of same; half natural size.
Fig. 16*c*. Section through stoma; × 65.

PLATE XXXIII.

Fig. 17*a*. Transverse section, leaf of *Pleurophyllum speciosum*, through rib; × 15.
Fig. 17*b*. Transverse section, leaf of *Pleurophyllum speciosum*, through mesophyll; × 15.
Fig. 18. Transverse section, leaf of *Senecio antipoda*; × 15.

PLATE XXXIV.

Fig. 19. Transverse section, leaf of *Phyllachne clavigera*; × 44.
Fig. 20. Transverse section, leaf of *Pratia arenaria*; × 44.
Fig. 21. Transverse section, leaf of *Gentiana cerima*; × 44.

PLATE XXXV.

Fig. 22*a*. Transverse section, leaf of *Myosotis capitata*; × 23.
Fig. 22*b*. Surface section of upper epidermis (*ep.*), showing hairs (*h.*); × 23.
Fig. 22*c*. Surface section of lower epidermis (*l.ep.*), showing stomata (*st.*), × 44.
Fig. 23. Transverse section, *Veronica benthami*; × 44.
Fig. 24*a*. Transverse section, *Plantago*; × 44.
Fig. 24*b*. Surface view of epidermis, showing stomata and hair; × 44.
Fig. 24*c*. Leaf of same; half natural size.

PLATE XXXVI.

Fig. 25*a*. Transverse section, leaf *Astelia*; × 44.
Fig. 25*b*. Transverse section, leaf *Astelia*.
Fig. 25*c*. Epidermis of *Astelia*; × 125.
Fig. 26. Transverse section, leaf of *Luzula crinita*; × 44.
Fig. 27*a*. Transverse section, leaf of *Scirpus aucklandicus*; × 44.
Fig. 27*b*. Plant of same; half natural size.

PLATE XXXVII.

Fig. 28. Transverse section, leaf of *Carex trifida*; × 44.
Fig. 29*a*. Transverse section, leaf of *Poa foliosa*; × 44.
Fig. 29*b*. Transverse section, showing stomata and papillæ; × 125.
Fig. 29*c*. Transverse section through bundle, showing endodermis and vessels: × 215.

LETTERING USED IN FIGURES

cut. Cuticle.
ep. Upper epidermis.
l.ep. Lower epidermis.
st. Stoma.
sb. Subsidiary cell.
h. Hair.
pap. Papilla.
st.l. Water-storage layer.
chlor. Chlorenchyma.
pal. Palisade tissue.
sp. Spongy tissue.
a.s. Intercellular air-space.
col. Collenchyma.
sm. Stereom tissue.
o.g. Oil-globule.
cr. Crystal of oxalate of lime.
r. Raphides.
c. Resin-canal.
b. Epithelial tissue lining canal.
par. Colourless parenchyma tissue.
p.s. Parenchyma sheath.
endo. Endodermis.
v.b. Vascular bundle.
xy. Xylem.
ph. Phloem.

Art. XLIX.—*Description of a New Native Grass.*

By D. Petrie, M.A.

[*Read before the Auckland Institute, 9th October*, 1905.]

Poa astoni, sp. nov.

A grass growing on coast cliffs, densely tufted, 15 in. high or less, with leaves equalling or exceeding the culms. Leaf-sheaths broad, compressed, thin, striate, glabrous, pale, continued at the edges and front into a rigid broadly triangular acute ligule. Leaf-blades filiform, involute, striate, glabrous, suddenly narrowed from the back of the sheath, the point of origin being marked by a joint; in age deciduous at the joint. In smaller forms the blades are shorter, more rigid, and almost acicular. Culms slender, few-jointed, striate, the joints short and constricted; uppermost leaf on culm long-sheathing. Panicle ovate or ovate-oblong, compact, 2½ in. long or less; panicle-branches 4 or fewer, terete, glabrous, swollen below the insertion of the spikelets. Spikelets crowded at the tips of the panicle-branches, pale, shining, shortly stalked, ¼ in. long, 5–6-flowered, flowers all sessile. Outer glumes half as long as the spikelets, pale and shining, nearly equal, broadly lanceolate, acuminate, glabrous, 3-nerved for two-thirds of their length. Flowering-glumes glabrous or finely pubescent, strongly 5-nerved, acuminate, the midrib delicately scabrid or almost glabrous, ciliate at the margins, with a scanty tuft of long hairs at the bottom of the back; this tuft sometimes absent. Palea 2-nerved, nerves ciliate, bifid at the top.

Hab. Rocky cliffs and reefs on the coast of Otago and Stewart Island—at Brighton, Taieri Mouth, Catlin's River, Waikawa, Bluff, and Paterson's Inlet; also at the Auckland Islands (*fide* T. Kirk, who contributed specimens from there to Mr. Cheeseman's herbarium).

Sir J. D. Hooker's *Festuca scoparia*, described in the "Flora Antarctica," appears to include two distinct grasses, the present grass and one that is confined to the southern off-islands, where it forms the principal coastal and upland tussock-grass on the Auckland, Campbell, and Antipodes Islands. As many of the characters contained in Hooker's description apply only to the latter, I conclude that it was the off-island tussock-grass that he meant to distinguish as *Festuca scoparia*.

Hackel recognised that *Festuca scoparia* was a true *Poa*. Cheeseman, who agreed with this view, has accordingly named it *Poa litorosa*, the name *Poa scoparia* being preoccupied. I assume that *Poa litorosa* is the off-island grass, which is not known to extend to the main islands of New Zealand, and cut out of Hooker's original species, the one here described.

I formerly referred specimens of the true *Poa litorosa*, Cheesm., given to me by the late Mr. T. Kirk, F.L.S., under the name of *Festuca scoparia*, Hook. f., and collected by him on the Auckland Islands, to my *Poa chathamica*. This mistake was due to misunderstanding the true relations of *Poa litorosa*, Cheesm., and the species here described.

An accurate description of *Poa litorosa* is much needed, but at present the material in the possession of colonial botanists is insufficient for the purpose.

Art. L.—*Appendix to the List of Seaweeds of Norfolk Island.*

By R. M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 5th July,* 1905.]

In vol. xxxiii of the "Transactions of the New Zealand Institute" there appears a list of the seaweeds of Norfolk Island. I have now a few more species to add to that list. Of the two species hitherto considered to be endemic, one, *Plocamium hamatum*, J. Ag., has recently been found on the Australian coast. Owing to an oversight in reading the proof, two species already listed in the paper were reinserted in the addendum. If these duplicates are removed from the list there remain thirty-three already recorded. To this list six have to be added, none of which are endemic, but they are all either Australian or widely distributed.

34. *Caulerpa racemosa* (Forsk.), W. van Bosse, var. *lætevirens* (W. van Bosse).
35. *Bryopsis foliosa*, Sonder.
36. *Hydroclathurus cancellatus*, Bory.
37. *Dictyota ciliata*, J. Ag., *forma* (dentibus sparsissimis et hic illic in phylla excrescentibus, ut in *D. patens;* ? = var. *humilis*, Grunow, Samoa, i).
38. *Ulva mematoidea* (Bory), Mont., var. *angustior* (Grun.) = *U. fasciata*, Delile.
39. *Cystophora uvifera* (Aresch.), form without vesicles (? shallow water).

I have again to thank Major Reinbold for his kind assistance in the identification of the specimens.

ART. LI.—*The Occurrence of Gold at Harbour Cone.*

By C. N. BOULT, B.Sc.

Communicated by Dr. P. Marshall.

[*Read before the Otago Institute, 8th August,* 1905.]

PLATES IX–XIII.

INTRODUCTION.

THE occurrence of gold in igneous rocks in New Zealand has been treated of in only one instance—that of the andesites of the Thames goldfields. In these the gold occurred in such small quantities as to require special means of determination, and existed only in the bands of rock immediately next to the walls of the lodes. On the Otago Peninsula, however, it occurs so plentifully in an alkaline syenite that the usual fire methods of assay can be used for its determination. This syenite occurs at the base of a mountain on the Peninsula called Harbour Cone.

Harbour Cone, as will be seen on the accompanying map, is situated about the centre of the Otago Peninsula, a volcanic peninsula which juts out from the coast of the South Island of New Zealand, here composed of sedimentary and ancient metamorphic rocks. The mountain lies at the back of the settlement of Portobello, and for the last fifty years its slopes have been farmed. It rises on one side from the Otago Harbour and on the other from Hooper's Inlet—a shallow sea-connected lagoon—at first in fairly gentle slopes, and from an elevation of 500 ft. rather steeply to its summit, 1,044 ft. high (trig.). The sides are for the most part grassy, but a portion of the central cone is covered with bush. The top is composed of a hard cap of solid rock. Its sloping sides and steep central cone give it the typical appearance of a volcano, and popular belief has always considered it an extinct one.

About 1874 the district was startled by the discovery of gold at Harbour Cone. Shafts were sunk and a drive made in a valley to the south-east of the summit, and a five-head battery was erected. However, after a short time it was seen that with the amalgamation process then in vogue profitable treatment of the ore was not possible, and operations were suspended. While the mine was being worked it was visited by Professor Ulrich, who reported very favourably on its prospects, but, despite this, work had to be abandoned. Since then nothing more has been done; the battery has been removed, and the shafts been allowed to fall in.

The mountain presents several difficulties for a geological examination. The surface of the rock composing it is everywhere covered with a thick mantle of decomposed rock and vegetable mould, which often renders the nature of the rock beneath a matter for conjecture. The evidence afforded by surface boulders has sometimes to be relied on, and, since they may have rolled some distance, deductions based upon them may not always be reliable.

A map showing any topographical features was not procurable, and in preparing a map of Harbour Cone and its environs it was necessary to first survey it. A contour map was made, the survey being made with aneroid barometer, prismatic compass, and Abney level. The position of all main points was fixed by means of cross-bearings, and contours then run at every 100 ft. from sea-level.

Two shafts existed in the valley where mining was originally carried on. The lower one was filled with fallen earth and logs, and hence was not accessible. The upper one was in a better state of preservation, but it was only possible to descend as far as the first cross-drive, as water had risen in the shaft below. It was thus possible to penetrate only about 5 ft. or 6 ft. into the auriferous rock, as will be seen in the section (Plate XIII).

It is hard to understand how the auriferous nature of the rock, or, indeed, how the rock itself, was ever discovered. The mountain-sides and all the valleys and stream-beds were carefully prospected, but no trace of the rock could be discovered on the surface, and the site of the mine renders it improbable that it was accidentally discovered in sinking for water. Panning-off of the creeks showed no colours of gold nor trace of pyrites, nor any other mineral that would point to the possible existence of gold.

The purpose of this paper is to describe the characteristics and occurrence of the auriferous syenite and associated rocks, and if possible to account for the occurrence of gold in the rock. The occurrence of gold in plutonic and volcanic rocks is a question bearing strongly upon its presence in lodes and allied bodies, and the occurrence of it in comparatively large quantities is a distinct peculiarity.

In rock-analysis the methods described by "Berringer's Assaying" were exclusively used, and in the assay of the syenite for gold and silver the usual fire methods were used. The assays were run with one or two check assays at the same time, and the assays and checks agreed almost exactly. The charge employed was,—

	Grains.
Ore ground to pass 100-mesh sieve ..	1,000
Sodium-carbonate (Na_2Co_3)	1,500
Borax ($Na_2B_4O_7$)	750
Litharge (PbO)	1,000
Powdered charcoal (C)	20

the silver value of the litharge being subtracted from the weight ot the bullion.

With each three assays a blank was run. Broken glass was powdered in the same mortar and on the same buckling-plate, and put through the same sieve and then assayed with the same charge. The result was the silver value of the litharge only, thus proving that no gold or silver had been introduced through the agency of the apparatus used.

General Geology.

The rocks of the Otago Peninsula and of its neighbourhood are in three distinct groups: (1) The basement schists of Otago; (2) the Tertiary sandstones; (3) the volcanic rocks of the Peninsula.

The schists of Otago form the vast pene-plain constituting Central Otago. Round the edges of this plain they are overlapped by beds of various ages, in all classes unconformably. The schist country commences at Brighton, about eight miles to the south of Dunedin. The schists are micaceous and very rich in quartz foliæ and veins. In places mica-schist gives place to chlorite-schist, usually in bands. Immediately north of Brighton the highly denuded surface of the schists dips beneath the Tertiary sandstones, which are almost horizontal. The foliæ of the schist itself are as a whole nearly horizontal in this area, though often showing local plications. The surface of the schists is undoubtedly the basement on which the Tertiary sandstones and volcanic rocks of the Peninsula were laid down. Dr. Marshall has reported fragments of schist occurring in the Port Chalmers breccia thrown up at a late stage of the eruptive period of the Peninsula, which proves that these rocks exist somewhere beneath. Thus this schist clearly underlies the Tertiary sandstones and volcanic rocks of the Peninsula, and it is on their highly denuded surface that the next series, the Tertiary sandstones, occur. The age of these schists is not yet fixed certainly. The two authorities on the matter are Sir James Hector, F.R.S., Director of the Geological Survey of the colony, and Captain Hutton, formerly Provincial Geologist of Otago. The former, in his "Outline of New Zealand Geology," which forms a summary of the work done by the Geological Survey Department, calls these rocks "clay-schists" of Lower Silurian age. In his "Geology of Otago" (1875) Hutton agrees with Hector, and calls the schists (Wanaka series) "Lower Silurian," but in his "Sketch of the Geology of New Zealand"* he gives their age as Ordovician. In a paper published in the "Transactions of the New Zealand Institute," 1899, he classes the schists as Archæan.

The Tertiary sandstones overlying these schists form the surface of a large block of country to the south and west of the Peninsula. On the Peninsula itself it is almost everywhere covered by tremendous outflows of lava. However, along the shore of the Pacific Ocean on the south side of the Peninsula it outcrops, forming cliffs on the top of which are the lava-flows. It is for the most part composed of rounded grains of quartz and finer detritus, and is in many places stained with oxide of iron, doubtless in part derived from the decomposition of the lavas above. It outcrops underneath the basalt at Sandy Mount (see map) at about 100 ft. above sea-level. In the "Geology of Otago" Hutton says that above the coal-deposits which occur in the lower portions of the series are a series of conglomerates (p. 48). These occur as outcrops at Kaitangata, but do not outcrop at Dunedin. In the early part of the winter of 1904 the writer was present at boring operations conducted on the flat comprising the lower part of Dunedin. A steam percussive borer was used, which in most cases reduced the rock pierced to fine powder. After passing through about 50 ft. of harbour-silt and volcanic rock in a decomposed state, and 100 ft. of sandstone, a very hard material was encountered which the borer would scarcely touch. Rounded and broken fragments of quartz were brought up by the pump, which evidently came from a quartzose conglomerate exactly similar to that found above the Kaitangata coal. Thus it seems that this coal exists not far below 150 ft. from the surface.

The sandstone is undoubtedly derived from the denudation of the schistose country at the back. The quartz pebbles forming the conglomerate above referred to are undoubtedly schistose in their origin, showing in places foliation-planes in the separate pebbles. The age of these sandstones is given by Hector as Cretaceo-tertiary in his work above referred to. Hutton ("Geology of Otago") classes them with the Oamaru series of Oligocene age. In the outcrop along the cliffs to the west of Dunedin fragmentary remains of fossil shells are to be obtained from the cliffs, notably *Pecten hochstetteri*, which

* Quart. Journ. Geol. Soc., May, 1885.

occurs in considerable abundance. This fossil has been identified by the Geological Survey and Hutton, but in a recent paper by Professor Park and Captain Hutton the identification is disputed, the name *Pseudamusium huttoni* being assigned to the fossil.

The remainder of the Peninsula is covered by a thick covering of volcanic rocks, forming lofty mountains and ranges. With the exception of basalt they are almost all very alkaline in character. Dr. Marshall in his section on geology in "Dunedin and its Neighbourhood" shows a map in which areas are covered by basalt, dolerite, trachyte, trachytoid phonolite, nepheline basanite, nepheline tinguaite, and kenyte, similar to that described by Gregory from Mount Kenya in East Africa. It is upon the very highly denuded surface of the Tertiary sandstones that these rocks outpoured, a fact shown by the variation in the level of the outcrops of the sandstones

Harbour Cone.

A glance at the map accompanying will show that this peak and its immediate neighbourhood is on the surface almost entirely composed of bostonite. The surface of the land is precipitous, and rises to Harbour Cone to form in appearance almost a typical denuded volcano and its bared solid pipe. The bostonite has a very great extent in this neighbourhood. It forms cliffs along the shore of the harbour to the east of Port Chalmers, and also tops the small hills surrounding the central peak. The central portion of the peak itself is composed of solid basalt extending down to the 900 ft. contour-line. Below this down to 750 ft. boulders of basalt cover the ground thickly, having been wedged off by frost and other natural agencies and rolled into their present position. On the northern slopes of the mountain an irregular area is occupied by a coarse breccia, very indurated, containing fragments of trachytoid phonolite and other rocks in large and small angular fragments. This is the Port Chalmers breccia, the greatest occurrence of which is on the peninsula on which Port Chalmers is built, which consists almost entirely of the breccia. The breccia also forms the upper portions of the small hill to the north-east of the main peak, as indicated on the map. The most important inclusion in the rock is large and small masses of alkaline syenite, showing that this rock must have enormous extent under the surface at an unknown depth, as the focus of the explosive eruption producing the breccia is somewhere near Port Chalmers.

The flanks of the mountain are pierced by numerous dykes. The position and nature of those occurring in the neighbourhood of the mine are shown on the accompanying map. They are very varying in their nature, in this small valley four varieties being met with—two varieties of trachytoid phonolite, one of bostonite, and one of tinguaite. The large auriferous mass of alkaline syenite rises to within a few feet of the surface here.

Along the hill-slopes to the west there are two outcrops of Tertiary sandstone indicated on the map. One of these has been quarried, so that the dip and nature of the rock is plainly visible. It is surrounded above and below by bostonite. The sandstone dips about 5° west, and where visible is in no way contorted or faulted. The end of the drive down the shaft shown on the map is walled with a sandstone crumbling in the hands and glittering with scales of a golden-yellow mica.

In the valley in which the mine is situated a chip was obtained from a boulder, which under the microscope exhibited peculiar characters. This probably was derived from a dyke of the rock, the dyke now being covered with loam, as no trace of it *in situ* could be discovered. A description of the petrographical characters of the rock will be found under "Petrography."

The first outflow in this area was undoubtedly the bostonite. The absence of any distinct flow-structures in it prevents any conclusions being arrived at as to its probable vent. It seems to have welled up and covered the neighbourhood with a deposit of enormous thickness. It flowed over a very highly uneven sandstone surface, as the outcropping of that rock at between 200 ft. and 300 ft., and its complete absence from the river-bed below, proves. It would seem that an original sea-cliff existed along that portion of the sandstone now outcropping. The top of this cliff now shows where the bostonite has weathered away.

Some time after the flow of bostonite the intrusion of the auriferous syenite took place. This intrusion is of large extent, since it occurs in fragments in the breccia thrown up at Port Chalmers as mentioned above. It probably forced up the sandstone in places, assuming dome-like prominences. This is probably the origin of the sandstone found in the drive in the mine, it being merely a portion of the main beds carried mechanically upwards. It is undoubtedly after the flow and consolidation of the bostonite that this intrusion took place, firstly because the bostonite has been altered along its junction with the syenite, secondly because this alteration is of small extent owing to the solid state of the bostonite.

Dykes were formed first of bostonite (see "Petrography"), which was probably intruded into the hot bostonite. The heat of the bostonite kept this dyke in a molten condition long enough for the magma to act on the first-formed crystals, as described under "Petrography." Then followed dykes of tinguaite and phonolite, in what order it is almost impossible to say. They were probably connected with the large eruptions of alkaline rocks on other parts of the Peninsula.

At a later stage followed an eruption of an entirely different nature. The basalt cap now topping the mountain is certainly the upper portions of a basalt-filled volcanic pipe, which communicated with the vent of a basalt-emitting volcano on the surface of the bostonite. After that enormous denudation went on and entirely denuded away any outflows of basalt which may have occurred. Some time during this period the explosive eruptions having their focus near Port Chalmers formed a deposit upon the partially denuded bostonite, which must have had a form then approximating to its present one, as a deposit of the breccia is found on the mountain-slopes. Since then more denudation has taken place. The breccia has, with the exception of the deposits shown on the plan, been entirely removed. A river has cut its passage through the flow, leaving the projecting hummocks now forming Quarantine Islands, which are entirely composed of bostonite. The hard pipe of basalt has resisted denudation while the bostonite all round it has been denuded away, thus giving to the mountain its present form. Thus, though the mountain has the typical form of a volcano and its projecting neck, it is far from probable that the materials composing its slopes have been ejected from its summit, but rather the white bostonite once formed a high plateau on the top of which was once a basalt-emitting volcano.

Thus, in this particular area, the order of outflow seems to have been—(1) bostonite; (2) intrusion of bostonite dykes; (3) intrusion of syenite mass, intrusion of tinguaite and phonolite dykes in unknown order; (4) outflow of basalt; (5) explosive eruptions producing breccia.

In giving the order of flow for the whole Peninsula, Dr. Marshall, in the work above referred to, writes—(1) trachite (bostonite); (2) basalt and nepheline basanites; (3) green trachytoid phonolite; (4) kenyte; (5) Port Chalmers breccia.

In the neighbourhood of Harbour Cone it seems probable that the phonolite and tinguaite dykes preceded the basalt, since the latter is remarkably fresh, while the former is very decomposed. The phonolite, however, lends itself to decomposition very readily, so that arguments based on relative decomposition are perhaps not reliable.

Note on Pseudamusium huttoni.

This is the most abundant and characteristic of the molluscs of the Dunedin Tertiary sandstones. It was originally identified by Hutton as *Pecten hochstetteri* described by Zittel ("Reise der 'Novara'—Palæontology," tab. xi, figs. 5*a* and 5*b*), but, as Professor Park* has lately pointed out, the shell does not correspond with Zittel's *Pecten hochstetteri*, the latter having one valve ribbed, while the former has both valves smooth. He has therefore given it its present name. A sketch of this shell is shown in Plate IX, fig. 1.

Petrography.

The volcanic rocks of Harbour Cone, like almost all those of the volcanic portion of the Otago Peninsula, show by their constituents a clear derivation from an alkaline magma, with the exception of the dolerite occuring at the summit of the mountain, of which the minerals do not indicate any alkaline chemical composition. The characteristic minerals of all are in many cases very strongly alkaline, the persistent occurrence of ægerine being most striking. The rocks, though differing in their mineralogical characters, indicate by their mineral composition a very close relationship in their chemical composition. These general resemblances point to the fact that the rocks come undoubtedly from one common magma situated below the district, and any differences in mineral composition must be explained by one of the theories of the differentiation of magmas. It is more than likely that a differentiation or a very great local variation in magmatic composition will account for the presence of the dolerite in such close proximity to this collection of alkaline rocks, as the difference in mineral composition is no greater than has been recorded in other flows not only in the same neighbourhood but issuing from the same vent.

For determining the plagioclase feldspars the following method was employed: Crystals showing albite twinning were selected cut as nearly at right angles to the composition plane as possible, which was indicated by adjacent lamellæ extinguishing between crossed nicols at right angles on either side of the albite plane. Several crystals were measured, and the maximum value for the extinction was compared with the table given by M. Levy ("Étude sur la Détermination des Felspaths dans les Plagnes minces, 1894," pt. ii, p. 29, *et seq.*).

Many of the rocks are nephelinitoid, but the nepheline is often ultra-microscopical. In cases where its presence was suspected a portion of the very finely ground rock was treated

* Paper read before the Otago Institute, 9th September, 1904.

with dilute hydrochloric acid on a microscope-slide, and then slowly evaporated to dryness. Under the high-power objective the presence of nepheline was indicated by the occurrence of small cubes of sodium-chloride.

Auriferous Syenite.

Two writers have mentioned this rock. Professor Ulrich, in the "Geology of Otago" (1875), by Hutton and Ulrich, describes it as "a coarsely crystalline rock composed of triclinic feldspar, hornblende, and some quartz, and being more or less densely impregnated with pyrites." Professor Park* describes the rock as a "grey porphyritic rock of plagioclase feldspar and hornblende," and names it a "porphyritic diorite." As will be seen below, there is no visible quartz in the rock, and it is distinctly neither porphyritic nor yet a diorite. In hand-specimens the rock is seen to be composed chiefly of feldspar and a dark mineral resembling hornblende in habit. It is seen to be impregnated sometimes rather freely with pyrites, showing on the fractured surface small flakes of the mineral. Some specimens, however, contain hardly any sign of pyrites. It is extremely hard and tough, being very difficult to fracture on account of the latter property. Under the microscope the rock is seen to be holocrystalline and of course texture. The bulk of the rock is composed of hypidiomorphic crystals of orthoclase, sometimes twinned on the Carlsbad law, and triclinic feldspar twinned rather coarsely on the albite law. These give a maximum extinction on the albite plane of 12°, being therefore oligoclase.

Throughout the body of the rock are very many small crystals, with irregular outline, of green transparent ægerine pleochroic, and showing the high birefringence characteristic of that mineral. Small rounded grains and needles of ægerine also occur abundantly.

Large and very decomposed crystals are present intergrown with the feldspar, and where these are not entirely decomposed they show the low birefringence and straight extinction of nepheline. In most cases, however, the mineral is entirely decomposed, and as it is not present in great abundance no absolute determination is possible.

Throughout the rock are large granular masses, in shape roughly that of typical hornblende. In most instances these are the same right through the mass, but in some cases a core of brown pleochroic hornblende is seen (Plate IX, fig. 2). It is possible to cut as many as ten sections without finding this feature. Where it occurs the mass presents the following charac-

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* Rep. N.Z. Geological Survey, p. 34 (1888–89).

ters : In the centre is the rounded core of horneblende, evidently from its pleochroic characters rich in iron. This is surrounded by a granular mass of opaque small rounded grains. Some of these grains are yellow in reflected light and others black, thus showing themselves to be pyrites and magnetite. They occur in about equal proportions. Between these grains small plates of green ægerine are to be seen, and needles and basal sections of clear apatite showing the typical uniaxial characters of that mineral. In places small pieces of the hornblende also occur interstitially. There is, besides, an isotiopic mineral whose characters show it to be analcite. It is a decomposition product such as would be expected in an alkaline rock.

These granular masses with their central core of hornblende form an interesting example of resorption zones. They are in no way the result of weathering, but result from the chemical effect of either the magma or superheated percolating solutions. The original hornblende has been acted upon by one of these agencies, with the resulting granular mass of ægerine, pyrites, and magnetite. Where no core of the hornblende remains the mass has a distinct hornblendic habit as a whole, being either a rounded mass such as would result from the cutting of an irregular crystal of hornblende parallel to the base, or else showing as a prism. Where interstitial hornblende remains, or where a core is left, its orientation is the same as that of the mass surrounding it. The apatite needles were originally in the hornblende, a feature very common in this mineral. The order of consolidation has been (1) apatite, (2) hornblende, (3) nepheline, (4) feldspar, (5) resorption action and consolidation of pyrites in the body of the rock.

Decomposition of the feldspars has produced kaolin and not sercite.

A chemical analysis of the rock gave as follows :—

	Per Cent.
SiO_2	50·8
Al_2O_3	22·5
Fe_2O_3	9·1
CaO	2·3
MgO	1·4
K_2O	3·9
Na_2O	5·7
	99·6

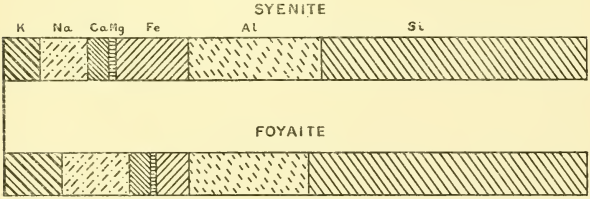
From a comparison of this analysis with those given by Rosenbusch* the rock most closely resembles an amphibole

* " Elemente der Gesteinslehre " (ref. p. 131, Analysis, p. 29, No 10). 1901.

foyaite from the Zwart Koppies (Transvaal, South Africa). The analysis of this is :—

	Per Cent.
SiO_2	53·73
(TiO_2)	0·09
Al_2O_3	20·35
Fe_2O_3	3·74
FeO	2·13
(MnO)	0·51
MgO	0·47
CaO	2·72
Na2O	7·94
K_2O	6·05
(P_2O_5)	2·02
Ph_2O	0·23

A comparison of these shows that this rock contains more silica and alkalis than the Portobello syenite and much less iron. It is to be remembered, however, firstly, that in the portion of the rock from which specimens were obtained chemical action has taken place with the formation of abundant magnetite and pyrites, which sufficiently accounts for the high percentage of iron. The rock also is in a decomposed state, and the alkalis have probably been removed to some extent. The lower percentage of silica, however, is only to be accounted for by an original difference in magmatic composition. The difference is so small that it does not preclude classing the rocks together. The total absence of all sphene, and consequently of TiO_2, is noteworthy, as this is usually an accessory in alkaline syenites. The greater amount of water is also explainable by the weathered state of the Portobello rock. Rosenbusch shows graphically the percentage of silicon and the metals in certain rocks in his work above referred to. A graphic comparison is given here of the Portobello syenite and the amphibole foyaite, where the resemblance is at once seen. The differences noted above are also to be noticed.

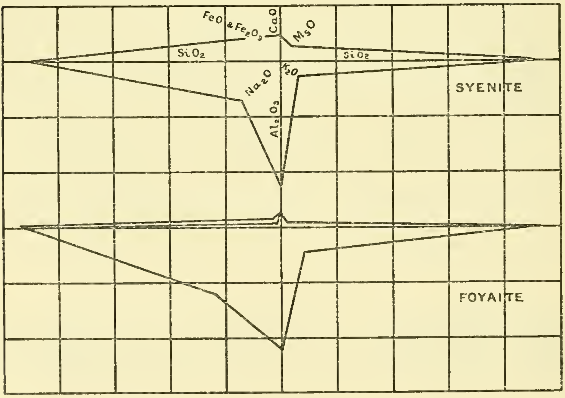


Graphic representation of chemical composition of Portobello syenite compared with foyaite (Brathagen). (After Brogger.)

The rock is also compared with a foyaite by the graphic method described by Brogger.* In this method the relative molecular proportions of the oxides were calculated from the analyses and then shown graphically, and the departures from a typical foyaite illustrated. The type taken is one given from Brathagen. The molecular proportions of the rocks are :—

	Portobello Syenite.	Foyaite (Brathagen).
SiO_2	0·8816	0·9250
Al_2O_3	0·2294	0·2201
Fe_2O_3	0·059	0·0064
FeO	..	0·0183
CaO	0·043	0·0286
MgO	0·035	0·0111
K_2O	0·042	0·0583
Na_2O	0·098	0·1732

The general similarity of the figures produced is to be noticed at once, and the high amount of iron, higher amount of potash, and lower of soda is to be seen.



Representation of amount of silicon and metals in Portobello syenite and foyaite. (After Rosenbusch.)

* "Die Eruptivgesteine des Kristianiagebictes," vol. iii (1898), p. 248, *et seq.*

BOSTONITE. (Plate XII, fig. 8.)

This rock, which, as mentioned in "General Geology," constitutes almost the whole of the mountain and neighbourhood, is, where not discoloured by iron-oxide, quite white. Two varieties exist. The first is a finely crystalline rock in which no crystals of feldspar can be seen with the unaided eye; the second a coarse variety in which large crystals of feldspar are seen, often ½ in. in length. This latter exists along the foot of the cliffs fronting the harbour, and it is doubtless to the deep burying and consequent slow cooling that this coarsely crystalline character is due. The remainder of the mountain is composed of the finer variety. Under the microscope the rock is seen to be composed of a number of polysynthetically twinned lathes of feldspar showing an evident flow structure. The rock is completely crystalline, the only other mineral present being magnetite in small granules and rounded masses. The rock is rather decomposed, the resulting product being white kaolin.

Ulrich in describing the district calls the rock a trachyte, to which family it undoubtedly belongs. Though the rock is a lava, its characteristic feldspathic mineralogical characters ally it to the hypabyssal bostonites. Harker ("Petrology for Students") defines these rocks as consisting "of feldspar, quartz never being abundant, and ferro-magnesium minerals being typically absent. Phenocrysts may or may not be developed, the bulk of the rock being a groundmass of little feldspar rods often with partial flow disposition." There evidently is a very close resemblance between this rock and the bostonites, except in their occurrence. The name has been applied to the rock even though it is a lava.

A determination of the alkalis gave soda (Na_2O) = 5·7 per cent., and potash (K_2O) = 4·2 per cent. Since the rock consists almost entirely of feldspar, this shows that the feldspar is anorthoclase, rather rich in soda, thus allying the rock to the ceratophyres.

A variety of the rock occurring in a band surrounding the syenite is seen to be much harder than the mass of the bostonite. It is densely impregnated with iron-pyrites. Under the microscope its structure is that of the last variety, but it has large masses and small grains of pyrites in it, together with patches of red iron-oxide. This band is certainly due to the altering effect of the intrusive mass of syenite.

BOSTONITE DYKE.

This is a rock which occurs in a large dyke 8 ft. across, as indicated in the map. Its course can be clearly traced for 5 or 6 chains, as the solid rock shows above the surrounding loam and soil.

In hand-specimens the rock is very coarsely crystalline, large crystals of feldspar, both orthoclase and plagioclase, being visible. Microscopically the rock is holocrystalline and very coarse in structure. Plates of orthoclase, often with Carlsbad twinning and polysynthetically twinned plagioclase, make up the bulk of the rock. The plagioclase gives a mean extinction angle on the albite twinning plane of $10\frac{1}{2}°$, and is therefore a variety of oligoclase. Dark patches of a granular nature consisting of magnetite grains occur in elongated shape throughout, often roughly assuming an amphibole form. These are penetrated by clear needles of apatite. These show another example of resorption zones. The outline of many of the granular masses is distinctly hornblendic, and the inclusion of apatite, a mineral often found piercing crystals of hornblende, points to the original existence of that mineral in the rock. Reaction of the magma has corroded the crystals, leaving only the magnetite and apatite, which evidently resisted the action. Differing from the syenite, there are no remaining cores of hornblende in the rock.

The naming of this rock is somewhat problematical. Originally .possessing amphibole, orthoclase, and oligoclase, together with its non-porphyritic holocrystalline and coarse nature, its characters would class it with the Plauen'cher grund type of Brogger. Among the hypabyssal rocks to which it belongs there is no rock to which it corresponds. The entire absence of trachytic structure, and its coarse nature and evenly developed crystals, render it different from any of the types of porphyries. In view of its almost wholly feldspathic nature, and the mixture of feldspars which clearly places it in the porphyries, it seems to be a coarse example of a bostonite.

The occurrence of the resorption zones in this as in the syenite seems to point to its intrusion into a still-hot bostonite lava. This surrounding hot material kept the magma surrounding the first-formed crystals, the hornblende, in a liquid condition, giving it time to act on the crystals, producing the resorption of them.

Though the name "bostonite" has been given to the rock, it is only on account of its association of feldspars, almost entirely feldspathic composition, and occurrence in a dyke, and not on account of its resemblance to typical bostonites.

TINGUAITE. (Plate XI, fig. 6; Plate XII, fig. 7.)

A dyke of this occurs as indicated on the map. Its course can be traced by small outcrops for a distance of 3 or 4 chains, though a determination of the width and dip cannot be made. In hand-specimens the rock is a dull-green, rather soft, and so finely crystalline that no minerals can be distinguished. Under the microscope the rock is holocrystalline and porphyritic. It consists mainly of a groundmass of a number of small crystals, rounded and irregular grains of ægerine, together with an immense number of fine needles of this mineral. The ægerine is of a grass-green colour, pleochroic and very birefringent. Small needles and lathes of feldspar occur in such small proportions as to render any determination of their mineralogical properties impossible. Throughout this groundmass are numerous porphyritic, hypidiomorphic, and idiomorphic crystals of hornblende, of a brown colour, strongly pleochroic. In places these are larger, with typical hornblendic characters. In parts of the section they form nests, each nest being composed of long laths and basal sections of hornblende surrounded by smaller needles of hornblende and small masses of ægerine. These are comparable to the basic secretions found in platonic rocks.

The order of consolidation was evidently—(1) hornblende (crystals of this having been separated out, there was evidently a tendency for others to form in its vicinity); (2) ægerine; (3) feldspar.

The stages of crystallization seem to have to a great extent overlapped, the ægerine having been in some cases contemporaneously crystallized with the hornblende in the nests, and the needles of ægerine and feldspar being consolidated together.

Treatment with acid and evaporation discloses cubes of sodium-chloride under the microscope showing the presence of nepheline. The name "tinguaite" has therefore been given to the rock.

Trachytoid Phonolite.

Two varieties of this rock occur as dykes, possessing distinct characters.

No. 1.—This occurs, as shown, near the mouth of the valley containing the mine. The course of the dyke is shown by the outcrop of the rock *in situ* from place to place along the line shown on the map. It appears to be about 7 ft. broad, and is inclined at about 10° to the vertical. It is in a state of great decomposition, so that the question as to whether it was ever nepheline-bearing is not to be determined. Under the microscope it is holocrystalline and porphyritic. The phenocrysts consist of scattered crystals of hornblende of rather irregular outline, though sometimes rounded or elongated. Most of these are of a deep-brown colour, intensely pleochroic, while others show a dark- and light-green pleochroism. An interesting feature of the rock is the occurrence of crystals showing a gradual change from a brown-coloured core to a green margin. The interior, then, possesses a lower extinction angle than the exterior. The groundmass consists in part of granular calcite with brilliant birefringence. This is derived from the decomposition of the feldspar—an intergrown mass of small plagioclase lathes and fine needles, irregular masses and grains of bright-green ægerine, showing brilliant birefringence. The feldspar is partially decomposed to calcite, and in places to calcite and kaolin, and is twinned polysynthetically on the albite law. It is of the variety oligoclase. No evident flow structure is present. Magnetite occurs in small rounded grains throughout. Though nepheline does not occur in the rock, it seems probable that when the rock was fresher it was present in small crystals; therefore the name "trachytoid phonolite" has been given to it.

No. 2 (Plate X, fig. 4) occurs in the valley just above the mine-mouth. It is not to be seen *in situ*, but its course is marked by a line of surface boulders extending as shown on the plan. It seems to have formed a dyke along this line. It is holocrystalline and porphyritic. The phenocrysts consist of large square and rectangular plates of orthoclase and large columnar crystals of oligoclase very finely twinned (maximum extinction on albite plane = 10°). Calcite frequently occurs in granular masses, often taking the orientation, both externally and internally, of the finely twinned oligoclase, a fact apparent between crossed nicols. The groundmass consists of an aggregate of plagioclase laths and needles and small irregular masses of green ægerine. The feldspars show a pronounced trachytic structure, and are twinned on the albite law. Treatment of the powdered rock with hydrochloric acid, on evaporation on a microscope-slide, shows under the high power small cubes of sodium-chloride, thus proving the existence of nepheline in very small crystals. On account of this the name "trachytoid phonolite" has been given to the rock.

Basalt. (Plate X, fig. 3.)

As mentioned under "General Geology," this rock forms the top of the mountain, and apparently extends down for an unknown depth, filling an old volcanic pipe. The rock in hand-specimens is seen to be very undecomposed; it is coarsely crystalline, and phenocrysts of feldspar and augite can be distinguished, the latter often of large size. Olivine is also distinguishable, but in far less quantity than distinguishes the basalt family as a whole. Under the microscope the rock is seen to be composed chiefly of mass of feldspar laths twinned on the albite law. They are all plagioclase, with a maximum extinction of 32½°, thus being a variety of labradorite of medium composition. These laths show a general flow structure, and wrap round numerous small hypidiomorphic crystals of augite. These laths are of a clear pale variety, showing the typical non-pleochroic and highly birefringent characters of that mineral.

In this mass of augite and plagioclase are large phenocrysts of augite, often quite idiomorphic, and showing the usual cleavage and characters. Olivine is also present throughout the rock in rounded grains and large rounded plates, but is not remarkably abundant. It is quite undecomposed, and is distinguishable from the augite with difficulty with ordinary polarised light, but under crossed nicols it shows a much higher birefringence.

A residuum of glass is present interstitially with the plagioclase laths. It is not present in great quantity, and is filled with small colourless beads. In places these unite to form colourless needles (margirites), and elsewhere to form dark-coloured rods which appear as small dark needles piercing the glass under the low-power objective.

The coarse crystallization and almost entirely holocrystalline characters of this rock ally it closely to the dolerites. The feldspar laths are much larger than are usually found in basalts and more typical of dolerites. The residiuum of glass and flow structure, however, class it with the basalts. The coarse structure is doubtless due to the fact that it has solidified in a pipe, the exposed portion now, perhaps, being originally many hundred feet deep. The flows from this pipe were no doubt much finer in their crystallization.

Under "General Geology" reference was made to a boulder found in the mine valley with peculiar petrographical characters (Plate XI, fig. 5). Its mineral constituents find no parallel among any rocks that are described in any of the standard works. In hand-specimens the rock is fresh and very dark, showing phenocrysts of augite in places, and small shining facets of a dark mineral under a magnifying-glass. Under the microscope it is seen to be holocrystalline and prophyritic. The phenocrysts consist of long polysynthetically twinned plagioclase with a maximum extinction on the albite plane of 19°, thus being andesine. Rounded plates of augite are scattered through the mass, and in places these are quite idiomorphic, and show unbroken crystalline outline. They are very pale green in colour, and non-pleochroic, with high birefringence.

Enclosing these phenocrysts are a mass of irregular grains of soda amphibole (probably hastingsite). They have a greenish-brown colour, and are very pleochroic. These have needles and small laths of andesine scattered throughout them, and form two-thirds of the bulk of the rock.

The order of crystallization has evidently been—(1) augite; (2) plagioclase phenocrysts; (3) plagioclase in the ground-mass; (4) amphibole. This order of crystallization is a variation from the normal, and somewhat suggests that of the diabases, though in them the last mineral to crystallize is the augite, and hornblende is rarely present. The rock seems to be most closely related to the phonolites and tinguaites, the soda amphibole taking the place of the ægerine common to those rocks, and nepheline not being represented. The acid nature of the feldspar prevents its inclusion with the diabases or Hohenbegger's teschenites, to which it has some affinities.

Its occurrence is only another example of the numerous varieties in which the crystallization of the magma beneath has resulted, and the determination of the respective formation of ægerine, soda amphibole, or nepheline is doubtless to be sought in the varying chemical composition due to magmatic differentiation.

The Occurrence of Gold.

An examination of the valley containing the mine leads to no sign of the auriferous rock on the surface, and no sign of pyrites or other possible gold-bearing minerals in the streams. A drive indicated on the map pierces the solid bostonite on the upper side of the valley. Two shafts are sunk lower down, about 15 ft. above the level of the stream-bed. The only one accessible was in a fair state of preservation, but, owing to water, could only be descended a distance of 20 ft., to the first cross-drive.

The following materials wall the shaft and the drive: (1) About 11 ft. of loam derived from decomposition of the bostonite, and from vegetable sources; (2) about 1 ft. of very decomposed bostonite; (3) cap of decomposed syenite; (4) solid syenite; (5) the last 18 ft. of the drive is walled with friable micaceous sandstone. (See Plate XIII, section AA, through drive.)

Along the border-line of the decomposed bostonite was to be seen a band about 3 in. in thickness of hard undecomposed mineralised bostonite, mention of which is made under "Petrography." The syenite is in almost every specimen obtained pyrites-bearing, and the mineralised bostonite is very rich in that mineral.

Assays of the samples obtained gave results as follows:—

No. 1. — Syenite showing in hand-specimens no visible pyrites (mean of three assays): Gold = 0·000066 per cent., silver = 0·00033 per cent.; giving, per ton of 2,240 lb.—gold = 10·45 gr., silver = 2 dwt. 1·74 gr.

No. 2.—Sample showing a few small specks of pyrites on fractured surface (mean of three assays): Gold = 0·00021 per cent., silver = 0·00099 per cent.; giving, per ton—gold = 1 dwt. 8·92 gr., silver = 6 dwt. 12·8 gr.

No. 3.—Sample showing plentifully specks and small flakes of pyrites on fractured surface, the richest sample in pyrites obtainable (mean of three assays): Gold = 0·0013 per cent., silver = 0·0056 per cent. ; giving, per ton—gold = 8 dwt. 11·8 gr., silver = 1 oz. 16 dwt. 14·1 gr.

No. 4.—Sample of mineralised bostonite. This rock is everywhere richly impregnated with pyrites, the fractured surface showing a brass-yellow colour. Mean of two assays: Gold = 0·0022 per cent., silver = 0·00051 per cent. ; giving, per ton—gold = 14 dwt. 8·9 gr., silver = 3 dwt. 3·8 gr.

Assay of the micaceous sandstone gave no sign of gold or silver.

From the above it will be noticed that the amount of the precious metals in the rock becomes greater as the amount of pyrites increases, and therefore it does not seem altogether illogical to infer that the gold and silver exist in the pyrites, being the so-called "sulphide gold." The proportion of gold to silver, about 1 : 5, in the syenite is almost constant, but in the mineralised bostonite the amount of gold suddenly increases, and the proportion of gold to silver becomes about 4 : 1.

The coarse crystallization of the syenite and its occurrence in the Port Chalmers breccia render it indisputable that this rock exists as a large intrusive mass under the district, and the only question to settle is whether the precious metals and pyrites were introduced into it subsequently to its consolidation or whether they were an original constituent of the liquid magma that was forced up. As mentioned under "General Geology," the intrusion of the syenite was probably subsequent to the outflow of the bostonite, and the former carried mechanically upwards a portion of the sandstone beds. Another possible solution for the presence of the sandstone is that the syenite was originally a surface of the crust, and on it the Tertiary sandstone was deposited, the bostonite afterwards flowing out and covering the sandstone: but this was probably not the case. Supposing a pyrites-bearing alkaline rock such as the syenite was exposed on the surface. The action of atmospheric water would have weathered the rock to a great extent, and subjected it to the well-known process of secondary enrichment. The pyrites as well as most of the gold would have been dissolved and redeposited in the deeper portion of the deposit, as has occurred in almost every exposed lode. The pyrites, however, in this deposit is unaltered at the surface ; and thus it is to be safely concluded that it has never been exposed to the direct action of a large amount of atmospheric water for any length of time.

From the presence of the resorption zones in the mass it is evident that chemical action on the hornblende crystals has taken place. This action may have occurred in three ways: (1) Action on infra-telluric crystals of hornblende by the magma or other agency before or during ejection; (2) action of the magma on the first-formed crystals after it had attained its present position; (3) subsequent action either of percolating water from above or below, or of water which constituted a part of the magma at a high temperature and charged with sulphur or sulphides.

The first of these is out of the question, since the movement of the mass during ejection would have detached and scattered throughout the mass the granular particles surrounding the hornblende core. It is certain that the presence of the pyrites in large masses in the rock is closely connected with its presence in small granular masses in the resorption zones, and therefore the formation of the zones was contemporaneous with the introduction of the precious metals. Taking it as probable that the mass was ejected after the outflow of the bostonite, we have two facts which have bearing on the matter: one the presence of a small zone of pyrites bearing syenite, the other the total absence of pyrites and gold and silver from the micaceous sandstone. The enrichment of the syenite and bostonite by ordinary vadose circulation is not probable, firstly on account of the absence of any possible gold-bearing bodies except the deeply buried schist, and secondly on account of the limited enrichment of the bostonite, a rock quite as porous as the syenite. There is absolutely no reason why the enrichment of this should have ceased a few inches from the junction of the rocks. The subsequent penetration of the mass by highly heated and sulphide-charged water from below, if this penetration occurred after the consolidation of the syenite, is for the same reason untenable.

It is thus to the magma or to some portion of the magma itself that we must look as the mineralising agent. Since the syenite has only been assayed in samples taken from the surface, it is impossible to say whether the rock may or may not be gold-bearing throughout its mass, and this leaves the solution of the problem to theoretical reasoning. However, we have seen that in all probability the reaction did not occur in the magma before ejection, and can conclude that the particular constituents which finally caused this action were not then concentrated enough to bring this about. When, however, the magma was forced up nearer the surface the mass would commence to solidify, and the portions of it which remained liquid longest would rise to the place of least pressure—that is, the portion nearest the surface. They would do this without difficulty in the semi-solidified viscous mass. At the surface they were, however, retained by the solid bostonite, which, however, they penetrated for a few inches, and the action causing the resorption zones took place. When this action ceased, partly from the disappearance of the hornblende crystals and partly from the formation of a surrounding shell of resulting granular products which prevented further action, the remainder of this liquid solidified in its turn, forming the pyrites visible to the unaided eye. Thus the action which could not proceed in the earlier stages of consolidation was rendered possible by the collection of certain constituents of the magma in the higher portions of the intrusion.

The complete absence of the pyrites from the sandstone is most striking, but when the great porosity of this rock is considered, and the consequent free circulation of water through it, a subsequent removal of the sulphide and gold and silver seems probable. This sandstone lying along the surface of the syenite as it was carried up would be the easiest channel for vadose water to circulate, and the passage of a large body of water for a comparatively short time has effected what the limited amount passing through the comparatively impermeable syenite and bostonite has not been able to do. Owing to this very porosity it seems probable that the sandstone was once mineralised to a much wider extent than the bostonite. The unstability of gold-bearing sulphides has been illustrated in every lode which carries sulphides, where the "iron cap" is often quite poor in precious metals the deeper portions of the reef being sometimes extremely rich.

The greater richness of the mineralised bostonite may be due to a differentiation of the reacting portion of the magma, comparable to Soret's classical experiment, when the more basic substances crystallized at the colder end of the tube, the "colder end" being the lower surface of the bostonite. A similar cause may have resulted in the differentiation of the gold and silver, the bostonite being so much richer in gold.

From theoretical grounds it would appear improbable that the auriferous belt in this rock extends to any great distance below the surface. Portions of the syenite ejected by the Port Chalmers breccia are in such a weathered state that all pyrites has been removed from them even if it was ever present. A general segregation of the aqueous solution of sulphides to the upper portions of the intrusion seems more probable than a general segregation throughout the mass, since no sign of any marked small segregations is visible on the small portion of the rock exposed. This aqueous solution was strongly alkaline as well as sulphide-bearing, as its reaction with the hornblende produced ægerine.

The occurrence of sulphides and gold in this syenite is a very striking feature. Its general alkaline properties render it more than probable that it is derived from the magma whence flowed the tinguaites, phonolites, basanites, and kenytes of the remainder of the Peninsula, and in these rocks so far absolutely no sign of pyrites has been discovered. A differentiation of a magma so complete as to include all the pyrites in one outflow seems improbable. The fact that all the other rocks were either ejected through dykes or volcanoes seems rather to show that the free communication with the air enabled the sulphides to escape, being either carried up mechanically with the steam present, or else being vaporised and escaping with the reduction of pressure consequent upon entrance to a surface-connected fissure. Whether the precious metals have also escaped or not is to be decided only by careful assays by fine methods on large bodies of these rocks, and theoretical considerations seem to show that traces of them, at least, will be found

The district is comparable to that of the Thames and Coromandel goldfields. There the country rock is andesite, and the existence of gold in this country rock is a disputed point. In the Otago Peninsula, however, the gold occurs comparatively richly in one rock at least ejected from the magma beneath, and the formation of auriferous lodes in this district was prevented, either on the lateral-secretion or ascension theories, only by the absence of lode-forming fissures and the circulation of a suitable gold-dissolving solution.

EXPLANATION OF PLATES IX–XIII.

Plate IX.

Fig. 1. *Pseudamusium huttoni*, reduced size, 4 : 3, with profile views.
Fig. 2. Microphotograph of syenite, showing resorption zone round hornblende.

Plate X.

Fig. 3. Microphotograph of basalt, crossed nicols.
Fig. 4. ,, phonolite, crossed nicols.

Plate XI.

Fig. 5. Microphotograph of undetermined rock, crossed nicols, showing augite and soda amphibole.
Fig. 6. Microphotograph of tinguaite.

Plate XII.

Fig. 7. Microphotograph of tinguaite, crossed nicols. *a*, hornblende nest; *b*, ægerine twin.
Fig. 8. Microphotograph of bostonite, crossed nicols.

Plate XIII.

Map of Harbour Cone.

Art. LII.—*On the Geology of the Clarendon Phosphate-deposits, Otago, New Zealand.*

By Arthur R. Andrew, B.Sc., A.O.S.M., Laboratory, Otago University School of Mines.

Communicated by Professor James Park.

[*Read before the Otago Institute, 8th August,* 1905.]

Plates IV–VIII.

Introductory.

The Limestone Quarries.—The Millburn district is well known throughout Otago by reason of its deposits of limestone, which have now been worked for more than thirty years. Numerous quarries have been opened up in various parts of the district, but there are only two in active operation at present—that of the Millburn Lime and Cement Company, near the Millburn Railway-station, and Wilson's quarry, close to the main road and about half a mile north of Millburn. The lime derived from the burning of the limestone is for the most part used for agricultural purposes, the Millburn Company alone producing lime suitable for building. The company has large works at Dunedin, and send there by rail all the lime they require for making cement; "land lime" nevertheless constitutes the bulk of their output. I understand that this company has been considering the possibility of using their limestone in the manufacture of calcium-carbide. As will be noted below, some of the limestone in their quarry contains a small amount of phosphoric acid, and in quarrying great care will be needed lest any of this stone should be sent to the carbide-works. In the manufacture of calcium-carbide from limestone, any phosphorus present associates with the carbide, and, when the latter is acted on by water to generate acetylene, forms compounds which mingle with the gas and burn with the production of a most disagreeable odour. The limestone is not used as a building-stone, as it is broken up into small blocks by the planes of lamination, stratification, and jointing, which are well defined and set close together.

Other Workings.—Other rocks in the district are also of economic importance, though in a less degree. The schist which forms the floor on which the later deposits were laid down is occasionally used for building walls and fences—a purpose for which its flaggy nature renders it suitable. The basalt which forms the cap of the hills is quarried and used for road-metal. In the early days of the diggings in Otago, the discovery of gold to the north near Lake Waihola caused a rush to set in thither, but it soon passed on, as the gold was not present in payable quantities.

Failure to recognise the Nature of the Phosphate.—It has long been considered possible that deposits of phosphate of lime should occur in this neighbourhood. It is stated that Sir James Hector, then Director of the Geological Survey, believed that a careful search would reveal the presence of rock-phosphate. Those who did search for it seem to have looked only for dark-coloured coprolite-deposits. Massive outcrops of rock-phosphate, some 20 ft. high, are plainly to be seen at several places. The manner in which the deposits escaped recognition now seems marvellous. A specimen of the phosphate was to be seen in the Otago Museum, labelled "decomposed limestone from Clarendon." The lime-burners found that the "decomposed limestone" crackled loudly in the kiln, and would not burn as it should have done. They sent a sample to their analyst, who estimated the calcium-carbonate in it; finding it low, he reported that the limestone was of poor quality, and not worth burning: he did not dream of testing for phosphate. One of the lime-burners, however, persisted in burning the decomposed along with the fresh limestone, and though he apparently used poor material for his work, still, the lime he produced gave just as good results to the farmer.

Discovery of the Phosphate.—Meanwhile, Mr. Ralph Ewing, of Whare Flat, Dunedin, had been travelling in America, and had inspected the phosphate-deposits of Florida. Returning to New Zealand, he speedily realised the true nature of the "decomposed limestone," and in June, 1902, he announced his discovery. Then the lime-burner and the farmer understood why the poor limestone made just as good a land-manure as the ordinary limestone.

In the neighbourhood the discovery naturally excited keen interest, and now the apparent reluctance to recognise the deposits of phosphate was succeeded by a great eagerness on the part of some of the landowners to discover them on their property. One farmer had heard that some of the phosphate is white and soft. In his fields there was a white, soft clay, formed by the weathering of the mica-schist which lay all around: he jumped to the conclusion that his "find" was phosphate. After some days (spent largely in receiving the congratulations of his less fortunate neighbours) he sent a sample to an analyst: his hopes vanished. Another landowner had heard that some phosphate was hard and flinty—so was a quartzite which lay in abundance around his house: he likewise drew a conclusion of his own. And yet a third thought that a reddish clay on his property might prove to be a red variety of the eagerly sought rock: the clay was due to the weathering of a basalt rich in iron.

Previous Investigation and Literature.—The district has been exceptionally free from geological investigation, and until the discovery of rock-phosphate attracted little attention. In 1862 Dr. Lauder Lindsay is reported to have delivered a lecture on "The Geology of the Tokomairiro and Clutha Districts," and to have mentioned the limestone at Millburn. I have been unable, however, to see an account of his lecture. In the Report of the Geological Survey for 1873* the "calcareous sandstone of Waihola Gorge" was mentioned, but no description was given. In 1875 Captain F. W. Hutton gave a passing notice to the limestone of Millburn†; he mentioned the occurrence of "an isolated patch of limestone on the side of the road at Waihola Gorge"; he noticed the occurrence in it of *Ostrea wullerstorfii* and *Lima lævigata.* Sir James Hector travelled through the district, but apparently saw nothing worth mentioning. In his "Outlines of New Zealand Geology"‡ there is no reference to Millburn or neighbourhood. In 1902, soon after the discovery of the rock-phosphate, Professor James Park§ visited the locality, and his report on the geology of the phosphate-deposits, published in 1903, was the first systematic description of the geology of this district.

Physical Geography.—To the south of Dunedin there is a line of coast-hills, varying in height from 500 ft. to 1,400 ft. Shut off by these hills from the sea are two long, somewhat narrow plains—the Taieri and the Tokomairiro—along the length of which run the main road and the Main Trunk Railway. The drainage of these plains finds an outlet to the sea through narrow gorges in the coast-hills. On the western side of the plains the hills rise abruptly, but between Clarendon and Millburn they jut far out towards the east, separating the two plains from each other, and forming the Waihola Gorge—the former name for Millburn. It is at the base of the protruding part of these western hills that the rock-phosphate mostly occurs. On the southern (Millburn) side of the gorge the hills rise sharply at first till the crown of the spur is reached, and then the spur runs in a north-west direction, attaining its greatest height at the Trig. Q. From the trig. another long spur runs down in an

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* Report Geological Survey N.Z. (1873–74): Progress Report xiii.

† Captain Hutton, "The Geology of Otago" (1875), p. 48.

‡ Sir J. Hector, "Outlines of New Zealand Geology" (1886).

§ Professor James Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 391.

easterly direction on the north boundary of the district, reaching the plain opposite Cemetery Hill. Between this spur and the former one the hills descend somewhat more abruptly to the plain. In the neighbourhood of the gorge a small cross-spur runs northward parallel to the road; the western flank of this spur was the site of the original discovery of rock-phosphate, and is now the scene of the greatest activity in the quarrying of the rock.

Formations of the District.

7. Rock-phosphate ..	Secondary origin ..	Recent.
6. Sandstone ..	Secondary origin ..	Recent.
5. Alluvium ..	.. ..	Pliocene.
4. Basalt ..	Oamaru formation ..	Lower Tertiary.
3. Calcareous series ..	Oamaru formation ..	Lower Tertiary.
2. Grits and conglomerates ..	.. ..	Lower Tertiary.
1. Foliated schist ..	Kakanui formation ..	Silurian (or older).

Summary.—The basement rock of the district consists of the foliated mica-schist which constitutes the greater part of the Province of Otago. On this basement thin patches of grit and conglomerate are irregularly distributed. Above these come glauconite sands, which gradually merge upwards into the limestone as they become less and less glauconitic. Above the limestone, which lies practically horizontal, there occur in various places a brown sandstone and patches of rock-phosphate, usually occurring together; their outcrops roughly follow the contour-lines, but rise towards the north-west along with the limestone. In many places the limestone is absent, the rock-phosphate then resting directly on the glauconite sands. The sandstone and the rock-phosphate are confined to the outer margin of the limestone, and do not extend beneath the basalt-flow which caps the western hills and forms occasional outliers on the hills of the eastern side. The low-lying portions of the schist are covered by the alluvium of the Taieri and the Tokomairiro Plains.

Schists.

Character of the Schist.—This rock may be properly termed a "chloritoid mica-schist."* In the hand-specimen muscovite is clearly seen along the foliation planes, but under the microscope it is scarcely apparent, the rock being then seen to consist mainly of alternating folia of chlorite and quartz. The quartz often surrounds fibrous masses of chlorite, which are elongated in a direction parallel to the plane of foliation. Rutile

* Rosenbusch, "Elemente der Gesteinlehre," p. 517.

is in many places quite abundant as minute inclusions in the quartz, mostly as stout prisms, but also as long narrow crystals. Many of the quartz crystals show by their undulose extinction that the rock has been subjected to great strain; the folia occasionally are contorted and puckered, but this character is not frequently observed.

Occurrence.—For a rock of such a great age the schist lies very flat, the average dip being about 10° in a westerly direction (W. 10, N. 10). The difference in the dips between the schists and the overlying limestone affords the only evidence of the unconformity that exists between these formations. Near Kiln Point the schist is traversed by two sets of approximately vertical joints which strike N. 13° W. and S. 13° E., and W. 22° N. and E. 22° S. respectively. The schist contains no trace of organic remains. The hills on the east of the gorge are composed entirely of schist; on the western side it is found outcropping from beneath the limestone in a few localities, as at the base of Cemetery Hill, between Cemetery Hill and Kiln Point, and near Sutherland's quarry. The schist forms the basement rock of the district, and to the north-west of the Trig. Hill it passes out from beneath the overlying formations and extends westward throughout the greater part of Otago.

Age.—Within the district we get no information as to the age, except that it is older than the limestone; it forms part, however, of the foliated schists of Otago, which Sir James Hector* in 1875 considered as a Kakanui formation of Upper Silurian age. In 1872 Captain F. W. Hutton† considered them as a Tuamarina formation, but in 1875‡ he considered them identical with the Upper Silurian Kakanui formation of Hector. In 1885 Captain Hutton§ classed the Kakanui formation as the lower part of the Takaka system, and thus of Silurian age. In 1886 Hector|| considered that they were the result of the metamorphism of Silurian and even younger rocks. In 1891 Hutton,¶ as the result of a more complete investigation, revised his former opinion and stated that they were of Archæan age. In 1896 Hutton repeated his former assertion, that they were Archæan. Professor Park refers the schists to the Silurian. Thus the geological age of the schist is dubious, the authorities on the subject being unable to agree as to whether it belongs to the Archæan or to the Silurian.

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* Hector, Quart. Journ. Geol. Soc. (1865), vol. xxi, p. 128.
† Hutton, Rep. Geol. Explor. N.Z. (1872–73), p. 31.
‡ Hutton, "Geology of Otago" (1875), p. 32.
§ Hutton, Quart. Journ. Geol. Soc. (1885), vol. xli, pp. 194, 198.
|| Hector, "Outline of New Zealand Geology" (1886), p. 83.
¶ Hutton, Trans. N.Z. Inst. (1891), vol. xxiv, p. 358.

Grits and Conglomerates.—The grits are tabloidal or flaggy in structure, and are composed of angular grains of quartz cemented by iron-oxide—limonite. Under the microscope the quartz-grains are seen to possess the same characters as the quartz-crystals of the subjacent chloritoid mica-schist—rutile needles, chlorite inclusions, and sometimes undulose extinction; muscovite is also seen in the grit. The quartz-grains of the grit have been derived in past geological times from the disintegration of the schist. In the conglomerate the quartz pebbles are well rounded, and as much as 0·75 in. in diameter. No fossils have been found in either grit or conglomerate.

These beds are seen only occasionally, as the surface-soil hides their outcrop; it is unlikely, however, that they attain any great thickness. They may be seen in two small cuttings on the road near Sutherland's farm (west of the Millburn lime quarry); they are also seen north-west from there on the hills in the schist country, and again they are seen north of Kiln Point. As seen at these places the thickness of the beds is never more than 1 ft., but near Sutherland's farm there are surface boulders of conglomerate 2 ft. and 3 ft. in diameter. These beds are more extensively developed ten miles to the south of Millburn, in association with the coal-seams of Fortification.

The only evidence of the age of the grits in the district is the fact that they underlie the calcareous limestone which is part of the Oamaru formation. As in the case of the schist, we must go outside the district to determine their age. In 1875 Hutton* considered the coal-grits, of which the Millburn grits are part, to belong to his Oamaru formation, of supposed Oligocene age. In 1880 Hector† considered the "island sandstone, forming the cover of the most important coal-bearing formations of New Zealand," as part of his Upper Greensand, of Lower Eocene age. In 1886 Hector‡ considered the island sandstone as part of his Cretaceo-tertiary system, comprising practically all the coal-measures of New Zealand. Professor Park in 1902 referred the grits to the base of the Oamaru formation, which he placed in the Upper Eocene.

Calcareous Series.

Occurrence.—The calcareous series follows the grits and conglomerates in conformable succession, the different members of the series being quite conformable to one another. Over most of

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* Hutton, "Geology of Otago" (1875), p. 47.

† Hector, "Corals and Bryozoa of the Neozoic Period in New Zealand" (1880), by J. E. Tenison-Woods: Pref., p. vi.

‡ Hector, "Outline of New Zealand Geology" (1886), p. 59.

the district they lie almost horizontal, though a slight inclination towards the south is noticeable on comparing the altitudes of the outcrops at different points. As the outcrop recedes from the plains, however, it becomes more and more elevated : this is best seen on the western outcrops, where the limestone rises 300 ft. in a horizontal distance of a mile ; at the highest outcrop the dip is seen to be S. 42°, E. 8°. On the east side of the road the calcareous strata dip steeply towards the schist, the dip varying from 15° to 45° in an easterly direction (E. 10° S.). There are three sets of well-developed joints, which aid the quarryman greatly in his work.

The top of the calcareous series has a very irregular surface of projecting pinnacles and deep depressions, which have been formed by the action of percolating waters containing carbonic-acid gas (CO_2) ; these have carried away the calcium-carbonate in solution, the greatest action having taken place along those channels where the percolation was strongest. As the mode of weathering throws considerable light on the question of the origin of the rock-phosphate, I will not describe it fully until discussing the origin.

Millburn Quarry.—The calcareous rocks are well seen in the Millburn quarry. The sequence of the various bands here was worked out in full, as I hoped to find a similar sequence in the other limestone outcrops of the districts. A general but not an exact resemblance was found; and I publish here the result of this work, in the hope that future workers may be aided by it in attempting to trace the sequence of the various bands in this district, and perhaps also in other districts. The typical sequence consists of the following, starting from the top :—

H (30 ft.). Siliceous limestone with glauconite-grains throughout ; *Brissus* (*Meoma*) *crawfordi* the chief fossil.

G (3 ft.). Hard limestone, less siliceous than H, with few fossils and no glauconite-grains.

F (2 ft.). Hard tough limestone, fairly siliceous : *Ostrea wullerstorfii* in abundance.

E (6·5 ft.). Tough limestone with *Magellania sinuata.*

D (3 ft.). Very pure knubbly limestone, with broken fragments of shells of *Brachiopoda.*

C (42 ft.). Pure white limestone, with *Brissus* (*Meoma*) *crawfordi, Pecten hochstetteri,* and remains of vertebrates.

B (35 ft.). Limestone, pure at first, but becoming more and more glauconitic towards the base, where it merges into A.

A. Unknown thickness of glauconite sands, with very few well-preserved fossils.

Band H.—From the top of the pinnacles of the quarry to about 30 ft. below the rock consists of a limestone containing an appreciable quantity of sand-grains and a few glauconite-grains. On treating a fragment of the rock with cold dilute hydrochloric acid (HCl), and examining under the microscope the finer residue which passed through a 90-mesh sieve, the insoluble matter was seen to consist of grains of quartz, limonite, and glauconite. One very interesting grain was thus isolated: it was a rock-fragment which originally had consisted of two well-developed crystals, one of plagioclase, the other of hornblende. The grain had been derived from a holocrystalline rock of very probably dioritic affinity. It is interesting to note that nowhere near the district is there now to be found a rock capable of furnishing such a grain. A partial analysis of the limestone gave:—

Insoluble gangue	5·50
*Phosphoric acid (P_2O_5)	0·15
Not determined	94·35
	100·00
*Equivalent of calcium-phosphate, $Ca_3(PO_4)_2$	0·33

This band contains a large number of fossils, of which *Brissus* (*Meoma*) *crawfordi* is the most common. The following fossils were identified from this band: (1) *Nodosaria subsimilis*, Stache; (2) *Cristellaria rotulata*, Lamarck; (3) *Textularia agglutinans* (?), d'Orbigny; (4) hexactinellid sponge; (5) *Graphularia robinæ* (?), McCoy; (6) *Actinometra*, sp.; (7) *Cidaris*, sp.; (8) *Echinus enysii*, Hutton; (9) *Brissus* (*Meoma*) *crawfordi*, Hutton; (10) *Liothyrina gravida*, Suess; (11) *Magellania lenticularis*, Deshayes; (12) *Pecten fisheri*, Zittel; (13) *Pecten hochstetteri*, Zittel.

Band G.—This consists of 3 ft. of a hard siliceous limestone —less siliceous, however, than H, and with no glauconite-grains. The laminæ are close together, and the only organic remains to be seen are fragments of shells.

Band F.—This band, which is only 2 ft. thick, is markedly siliceous, and splits with difficulty. *Ostrea wullerstorfii* is confined to this band, and is very conspicuous. The fossils identified were (1) *Liothyrina gravida*, Suess, sp.; (2) *Ostrea wullerstorfii*, Zittel.

Band E.—This is a tough limestone, 6½ ft. thick, with the laminæ somewhat indistinct. It is speckled with glauconite, especially in its lower portion; in the latter I came across a small coprolite, rich in phosphate of lime. The conspicuous fossil of this band is *Magellania sinuata*, the others being but rarely found; those identified were (1) *Magellania sinuata*, Hutton; (2) *Pecten hochstetteri*, Zittel; (3) *Pecten williamsoni*, Zittel; *Scalaria browni*, Zittel; (5) *Scalaria lyrata*, Zittel.

Band D.—This is a rough knubbly limestone, 3 ft. thick, which in general appearance looks very much like a coarse conglomerate, with limestone pebbles and matrix. The pebbles of this conglomerate are about 3 in. in diameter, and slightly rounded; they consist of a pure white limestone, probably identical with that of band C. The limestone forming the matrix of these pebbles is less pure and is freely speckled with glauconite; it resembles the limestone of band E, immediately above. The junction of this band with the subjacent C is not so clearly defined as its junction with the overlying E. It forms a strongly marked band around the face of the quarry, and has a slight dip (0° 43′ in a direction E. 9° N.).

In former times, after band C had been laid down, it would seem that it had been raised to near the level of the waves, which pounded fragments off its upper surface, rounded them, and spread them evenly out. Afterwards, conditions having changed, the coral mud which now forms band E was deposited over the area; it first filled up the spaces between the rounded fragments and then spread itself over them to a depth of 6½ ft. The only fossil traces found in D consist of fragments of the shells of *Brachiopoda.* This band is also distinguishable in Wilson's quarry, but is not so clearly marked.

Band C.—This is the principal band at the Millburn quarry, where it extends 42 ft. upward from the floor. It is regularly laminated, the laminæ being from 2 in. to 5 in. apart. When freshly quarried the laminæ often show a faint pink or greenish tint, which rapidly disappears on exposure. An analysis of this limestone gave the following:—

Insoluble gangue	2·21
Lime (CaO)	54·12
* Carbon-dioxide (CO_2)	42·86
† Phosphoric acid (P_2O_5)	0·018
	99·208
Equivalent to—	
* Calcium-carbonate	97·41
† Calcium-phosphate..	0·039

The following fossils were identified from this band: (1) *Nodosaria subsimilis*, Stache; (2) *Cristellaria rotulata*, Lamarck; (3) *Textularia agglutinans* (?), d'Orbigny; (4) *Cidaris*, sp.; (5) *Brissus* (*Meoma*) *crawfordi*, Hutton; (6) *Serpula*, sp.; (7) *Magellania lenticularis*, Deshayes; (8) *Magellania sinuata*, Hutton; (9) *Magellania marshalli*, nov. sp.*; (10) *Cucullea alta*, Sowerby; (11) *Pinna distans*, Hutton; (12) *Pinna neozelanica*, Gray; (13) *Pecten beethami*, Hutton; (14) *Pecten chathamensis* (?), Hutton; (15) *Pecten diffluxus*, Hutton; (16) *Pecten fischeri*, Zittel; (17) *Pecten hochstetteri*, Zittel; (18) *Pecten williamsoni*, Zittel; (19) *Lima colorata*, Hutton; (20) *Crepidula* (*Janacus*) *unguiformis*, Lamarck; (21) *Natica callosa* (?), Hutton; (22) *Voluta*, sp.; (23) *Notidanus gigas*, Sismonda; (24) *Odontaspis incurva*, Davis, sp.; (25) *Lamna* (?) *lanceolata*, Davis; (26) *Lamna*, sp.; (27) *Oxyrhina von haastii*, Davis; (28) *Trygon* (?) *ensifer*, Davis; (29) *Squalodon grateloupi* (?), Pedroni.

Band B.—As we descend from the base of the pure white limestone C the rock becomes more and more glauconitic, and less and less calcareous, till it passes gradually into the glauconite sands A, 35 ft. below. The transition is very gradual, and no definite line can be assigned as the junction between the pure limestone C and the glauconitic limestone B. Planes of stratification are well marked in this band, the laminæ being horizontal and about 3 in. apart. This band is not quarried, as the large proportion of glauconite renders it of inferior quality.

The fossils identified in this band were—(1) *Orbitolites*, sp.; (2) *Cristellaria rotulata*, Lamarck; (3) *Textularia agglutinans* (?), d'Orbigny; (4) *Cidaris*, sp.; (5) *Serpula*, sp.; (6) *Pecten diffluxus*, Hutton; (7) *Pecten hochstetteri*, Zittel; (8) *Lima colorata*, Hutton; (9) *Odontaspis incurva*, Davis, sp.; (10) *Lamna* (?) *lanceolata*, Davis; (11) *Carcharodon auriculatus*, Blainville.

Band A.—This, the glauconite sand, is composed of small rounded grains of glauconite with an admixture of quartz and calcite. It is devoid of stratification, and its thickness could not be determined.

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* *Magellania marshalli.* — Length, 2 in.; breadth, 1·95 in.; height, 0·80 in. Shell orbicular, smooth or with a few concentric markings near the margin; margins even; valves equally convex; beak solid, slightly curved and laterally keeled; foramen complete and of moderate size; deltidium large, conspicuous, and formed of two plates; loop elongated and reflected; medial septum of dorsal valve very prominent. This species is most closely allied to *M. concentrica*, which Hutton (Cat. Tert. Moll. N.Z., p. 35) describes as "shell oval, concentrically striated . . . length, 1·65 in.; breadth, 1·30 in.; height, 0·80 in." *M. marshalli* differs in being orbicular and flatter in shape, and in not having concentric striations over its whole surface. The only other described species to which *M. marshalli* is at all similar is *M. lenticularis*, from which it is distinguished by the characters of beak and foramen, which in the latter are—"beak small, recurved; foramen very small." This is a hitherto undescribed species, and I have much pleasure in naming it *M. marshalli*, after Dr. Marshall, of Otago University.

The following fossils were identified in this band, but the specimens collected were very much weathered and mutilated: (1) *Serpula*, sp.; (2) *Venus oblonga* (?), Gray; (3) *Dentalium mantelli*, Zittel; (4) *Turbo granosus* (?), Lamarck.

Professor Park* separated the calcareous series at Millburn into (*a*) limestone, (*b*) glauconitic sandstone. As stated above, however, the glauconitic limestone B affords such a gradual and complete transition between the two that it seems hardly possible to say where the glauconite sand ends and where the limestone begins. Hence I have thought it better to consider the sand as forming the termination of the calcareous series.

Glauconite or Chlorite?—Dr. Maclaurin,† of the Colonial Laboratory, in publishing an analysis of a sample of limestone from this quarry, and apparently from the upper part of band B, describes it as "a whitish limestone dotted with a large number of greenish-black particles (chlorite)." Professor Park‡ had before this described the mineral as glauconite. I isolated a small quantity of the mineral and made a partial analysis of it, as under:—

Silica	49·41
Water (combined)	10·20
Not determined	40·39
	100·00

According to the analyses of different samples given by J. D. Dana,§ the amount of silica in chlorite (penninite) lies between a maximum of 35·31 per cent. and a minimum of 29·89 per cent. The mineral cannot therefore be chlorite (penninite); not is it possible for it to be any other member of the chlorite group of minerals, for stilpnomelane contains the highest percentage of silica, and that amount never exceeds 45·61 per cent. On the other hand, the published analyses of glauconite show an amount of silica ranging from 46·58 to 52·86 per cent., and in the mineral we are considering we find 49·41 per cent.—well within these limits. Again, paying attention to the amount of combined water in the minerals, we obtain further proof that our mineral is glauconite and not chlorite. In chlorite (penninite) the amount of water ranges between 11·74 and 16 per cent., both figures being higher than that found with the Millburn mineral. The analysis confirms Professor Park's determination.

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* Professor James Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 394.
† Maclaurin, 36th Ann. Rep. Col. Lab. (N.Z.), 1903, p. 9.
‡ Professor James Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 394.
§ J. D. Dana, "System of Mineralogy," pp. 683, 653, 658.

The appearance of the grains under the microscope is that of glauconite, not chlorite. They are rounded, and green-coloured with a tinge of yellow, with a faint scarcely perceptible pleochroism. In a few of the sections examined the mineral is seen filling the chambers of *Cristellaria rotulata.*

Age of the Series.—All the species that are found fossil in the district occur at the Millburn quarry. They show that this series should be correlated with the Oamaru formation.* Out of the thirty-five species which I determined at Millburn, thirty had been described from the Oamaru formation in other districts. As to the geological age of this Oamaru formation, opinions are divided. In 1850 Dr. Mantell, Professor Morris, and Professor R. Jones considered it either Eocene or Upper Cretaceous. In 1865 Dr. Hector† considered it Miocene. In 1865 Dr. Zittel and Dr. Stache considered the northern equivalents of this formation as Oligocene or Upper Eocene. In 1866 Hector split up the formation, calling some Upper Pliocene, some Lower Pliocene, and some Miocene. In 1870 Hector‡ considered the Oamaru rocks as Upper Tertiary; the Waitaki, Tokomairiro, Caversham, and Wakatipu rocks as Lower Tertiary. In 1871 Hector§ placed the Oamaru formation as the closing member of his Cretaceo-tertiary system. In 1872 Hutton considered the Waitaki and Wakatipu members as Lower Oligocene, and the Oamaru, Caversham, &c., members as Upper Eocene. In 1875 Hutton|| considered it doubtful whether the Oamaru formation was Upper Eocene or Lower Miocene, but he inclined to the latter belief on account of the presence of forms such as *Carcharodon megalodon.* In 1879 Von Haast¶ considered it Upper Eocene. In 1880 Hector** called it Upper Eocene, and has kept to that opinion ever since. In 1885 Hutton†† considered it Oligocene, and has repeated that opinion. In 1902 Park‡‡ referred it to the Upper Eocene.

The question of age thus seems to be narrowed down to an issue between the closely allied Upper Eocene and Oligocene, with high authority supporting each opinion.

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* Hutton, "Geology of Otago" (1875). p. 46.

† Hector, Quart. Journ. Geol. Soc. (1865), vol. 4, p. 128.

‡ Hector, "Catalogue Colonial Museum" (1870).

§ Hector, Trans. N.Z. Inst. (1871), vol. iv, p. 245.

|| Hutton, "Geology of Otago" (1875), p. 54.

¶ Von Haast, "Geology of Canterbury and Westland" (1879), p. 315.

** Hector, Preface to Tenison-Wood's "Corals and Bryozoa of New Zealand" (1880), iii; "Outline of New Zealand Geology" (1886), p. 53.

†† Hutton, Quart. Journ. Geol. Soc. (1885), vol. xli, pp. 194, 206; Trans. N.Z. Inst. (1899), vol. xxxii, p. 169.

‡‡ Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 393.

Basalt.

Occurrence.—The basalt sheet overlies the calcareous series and forms the cap of the higher hills. It is practically continuous on the west side of the main road, running down from the Trig. Q to the lower levels. Outliers occur at Cemetery Hill, Kapiti, and behind Strain's farm. Beneath Trig. Q it must be at least 300 ft. in thickness.

Character.—The basalt is finely grained, with a sharp clean fracture. At Cemetery Hill it has a columnar structure with rude hexagonal jointing. Under the microscope the rock from Cemetery Hill is seen to consist of broad plates of a basic plagioclase wrapping round and enclosing crystals of augite, anomite, magnetite, olivine, and serpentine. The plagioclase, which forms the greater part of the groundmass, is a very basic variety, probably bytounite. Augite is the most common coloured constituent of the rock, and has the usual characters. Anomite, a rather unusual variety of biotite, occurs here in irregular flakes with intense pleochroism. Magnetite is very abundant. Olivine is not at all common, and neither is its decomposition product serpentine. I looked carefully for apatite in every slide, but was unable to see it; neither did micro-chemical tests reveal the presence of phosphorus.

Nearly thirty slides were examined from various parts of the district to see if there was any variation in the basalt. Differences were detected, but these were not of great importance. At Stony Knob magnetite is not so abundant as at Cemetery Hill, and occurs chiefly as specks and granules, not crystals; anomite is less abundant; the broad plates of plagioclase are not so conspicuous; while well-defined feldspar-laths with albite twinning become common. At Trig. Q plagioclase is abundant as minute stout lath-shaped albite twins; anomite is entirely absent. Near Williamson's magnetite becomes very abundant; olivine becomes common, while the plagioclase is present only as albite twins, anomite is entirely absent. At Strain's and near J. Gray's farm the rock is much altered by weathering: the feldspars are abundant as stout crystals; the augite is mostly decomposed; the olivine is changed to serpentine; and the whole mass of the rock is stained a yellowish-red by iron-oxide. At Table Hill, however, four miles south-west from Millburn, the structure changes to that of a fairly coarse dolerite, with labradorite as the most prominent phenocryst; augite is here confined to the groundmass, which contains no glass; magnetite and olivine are common.

Chemical Investigation.—On treating the powdered basalt with dilute hydrochloric (HCl) or sulphuric (H_2SO_4) acids, gelatinization takes place in a most pronounced manner. A pinch of about 0·5 gramme powder was placed in a test-tube and covered with 0·5 in. of 50 per cent. HCl. It was brought to the boiling-point and then allowed to cool; by the time it was cool it had formed a thick jelly, and test-tube could be inverted at an angle of 45° from the vertical; five minutes later it could be held upside down without any movement of the jelly taking place. To the hot solution obtained by boiling the powder with HCl, H_2SO_4 was added; part was allowed to stand for some days, when a quantity of gypsum needles were thrown down; part was at once evaporated to dryness on a glass slide, and crystals of gypsum and halite were then detected under the microscope.

A sample of the powder was next boiled for five minutes with dilute HCl, filtered and well washed; the residue contained colloid silica, which was dissolved by boiling for fifteen minutes in strong KHO; this residue was then filtered and washed, and the filtrate evaporated to dryness. Each of the three portions thus obtained was separately analysed, with the following result:—

—	Insoluble in HCl.		Soluble in HCl. Solution.
	Insoluble in KHO. Gangue.	Soluble in KHO. Colloid Silica.	
Silica	22·74	17·36	5·52
Alumina and iron ..	9·05	..	23·10
Magnesia	2·85	..	6·42
Lime	5·19	..	4·42
Soda	2·40	..	0·79
Potash	1·06	..	0·25
	43·29	17·36	40·50
	Total = 101·15		

The powder that was not dissolved by the HCl was found under the microscope to consist of augite and a little magnetite, so that the minerals which dissolved so readily were plagioclase, olivine, and magnetite.

The results of analyses of the basalt are as follows :—

—		1.	2.	3.	4.	5.
SiO_2	..	42·19	45·02	44·91	44·04	45·62
TiO_2	..	0·87	0·87	0·87	0·87	..
Al_2O_3	..	18·00	17·78	17·59	17·79	
Fe_2O_3	..	7·73	6·61	8·07	7·47	32·15
FeO	..	8·67	8·72	9·08	8·82	
MgO	..	7·06	6·29	6·41	6·59	9·27
CaO	..	9·27	8·76	7·88	8·64	9·61
Na_2O	..	3·15	3·82	3·37	3·45	3·19
K_2O	..	1·05	1·16	1·58	1·26	1·31
H_2O	..	1·35	1·57	1·54	1·49	0·20
		99·34	100·60	101·32	100·42	101·35

1. From Stony Knob. 2. From Stony Knob : S.G. = 2·957. 3. From Stony Knob. 4. Average of 1, 2, and 3. 5. Cemetery Hill : sum of results of the last table. (Only one estimation of TiO_2 was made.)

These results show that the basalt is 2 or 3 per cent. poorer in CaO than a normal basalt, but otherwise it coincides fairly closely with standard analyses, such as those given by Rosenbusch.*

Age of the Basalt.—Captain Hutton† considers that toward the end of his Oamaru formation great volcanic activity took place in the neighbourhood of Dunedin, resulting in the basalts at, *inter alia*, "the head and both sides of Waihola Lake." This flow is connected with the basalt-flow at Clarendon, and we may consider the latter as belonging to the close of the Oamaru formation, and thus either Upper Eocene or Oligocene. There is no evidence in this district to show what interval of time elapsed between the deposition of the calcareous series and the extrusion of the basaltic flow. Captain Hutton does not give the evidence on which he bases his opinion of the age of the eruptive rocks round Dunedin ; he does, however, show that the volcanic activity at Oamaru was of this age. Professor Park mentions that the basalt rests on the mica-schist, and on different members of the Oamaru formation, which was elevated and denuded prior to the emission of the flow. For this reason he places the eruption of the basalt in the Upper Miocene or Pliocene.

* Rosenbusch, "Elemente der Gesteinlehre," p. 322
† Hutton, "Geology of Otago" (1875), p. 56.

Alluvium and Sandstone.

Alluvium.—Over the low-lying parts of the district the alluvial deposits of the Taieri and Tokomairiro Plains overlie the foliated schist; their thickness must be considerable, but it could not be determined in this district. Captain Hutton considers the alluvium of these plains as of Pliocene age.

Sandstone.—At several parts of the district a brown sandstone is found above the limestone. It outcrops clearly in two places—at J. Gray's farm, and on the western hill which juts out to form Waihola Gorge; elsewhere the sandstone reveals its presence only by loose boulders on the surface. Professor Park* considers that this is an original formation, deposited in shallow water on top in succession to the limestone. He says, "From the upper surface of the limestone to the basalt cap there is an interval of 120 ft. to 150 ft., apparently occupied by a yellowish-brown sandstone, the character and disposition of which could not be ascertained on account of its outcrop being obscured by a heavy slope deposit of black earth mixed with sand. In the Oamaru and Weka Pass districts, where the sequence of Lower Tertiary strata is very complete and characteristic, the Oamaru and Weka Pass calcareous sandstones, which, as we have seen, are the time-equivalents of the Millburn limestone, are followed quite conformably by the Hutchison quarry or Mount Brown beds, which consist of yellowish-brown calcareous sandstone containing a rich assemblage of marine forms. This overlying series is so closely associated with the Oamaru series that it cannot be regarded as a separate formation, but only as the closing horizon of the Oamaru series itself. Until something more definite is ascertained about the sandstone lying above the limestone on the Horse-shoe Estate, it may be correlated with the Hutchison quarry horizon of the Oamaru formation."

A careful examination of the district has led me to differ from the above views of Professor Park, and has forced me to believe that the sandstone was not laid down as sandstone, but that it is a secondary deposit, formed, where conditions were favourable, from the weathering of the subjacent limestone. When the limestone weathered away, the quartz-grains in it were left behind and formed sands, which were afterwards cemented together by iron-oxide to form a compact sandstone. The following are the reasons which have induced me to differ from Professor Park's views, and to advocate the theory of a secondary origin:—

1. In this sandstone we do not find several features which we ought to find in a normal sandstone deposited in shallows by

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* Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 396.

running water, or spread over a land-area by torrential rains. (*a.*) No traces of stratification, false bedding, ripple-marking, &c., are to be found. (*b.*) The joints are poorly developed and not at all distinct. (*c.*) No fossils whatever have been found. Of course, many true sandstones do not contain fossils, but the Millburn sandstone has been provisionally correlated with the "Hutchison quarry-beds, which in places contain a rich assemblage of marine fauna," and this fauna the Millburn sandstone does not contain, so far as is known at present

2. Sandstones are relatively hard rocks, and offer great resistance to the agencies of denudation : hence in horizontal stratified rocks we find sandstone bands marked by terraces and cliffs. The Millburn sandstone is extremely hard and compact ; had it been laid down in Lower Tertiary times, as Professor Park thinks, it would now form prominent outcrops above the limestone. Instead, we find "an interval of 120 ft. to 150 ft., apparently occupied by a sandstone . . . its outcrop being obscured by a heavy slope deposit." The two outcrops that do occur are far indeed from being prominent. The Millburn sandstone, then, does not form outcrops as it should do supposing that it was formed in Lower Tertiary times.

3. Glauconite-grains are fairly abundant in the sandstone. A normal sandstone is laid down in shallow water on the margin of a land-area, and does not often contain glauconite, which is a mineral characteristic of deposits formed in deep water. On the other hand, a small number of grains of sand may be carried out to deeper waters, where coral mud is being deposited, accompanied by glauconite : this would form a limestone containing a small amount of silica and glauconite.

4. At the Millburn quarry I found that the depressions of the limestone are filled with brown sands, which are derived from the weathering of the subjacent limestone. Water containing carbon-dioxide has dissolved away the calcium-carbonate and left behind the insoluble quartz and glauconite, the glauconite gradually losing its green colour as it decomposes to form ferric oxide. That these brown sandstones have been derived from the weathering of the limestone is certain, for it is not uncommon to find patches of green sand still undecomposed in their midst, and the latter are undoubtedly formed from the limestone. They are afterwards, I believe, cemented together by iron-oxide, derived partly from the weathering of the glauconite, partly perhaps from ferruginous percolating waters. The percolating waters of this district do contain iron, as is shown by the occurrence of at least two ferruginous springs flowing from beneath the basalt cap.

5. The grains of the sandstone are identical in character with those of the top band of limestone at Millburn quarry. On dissolving away the calcium-carbonate of the limestone in cold dilute HCl, and on examining the residue, the quartz-grains of both limestone and sandstone are seen to be similar—the same shape, the same size, the same colour. Glauconite-grains occur in both. The sandstone contains much more limonite than the limestone, but that is to be expected on the supposition of its subsequent cementation with iron-oxide.

6. The brown sandstone often contains a small amount of lime-phosphate; often, too, as at the Millburn Company's phosphate-workings, grains of sand are cemented together by lime-phosphate to form a poor-grade rock-phosphate (25·87 per cent.). Let us assume that the sandstone is a Lower Tertiary deposit, and this fact will lead us into difficulties. It is not probable that the sandstone would originally be phosphatic, for it contains no fossils; and a sedimentary rock, if phosphatic, has derived its phosphate of lime from the numerous animals which inhabited its seas. The limestone contained many fossils, and also a small amount of phosphate, disseminated through it, as has been shown above. The basalt, which lay on top of everything else, contained no phosphate. The sandstone then, containing no phosphate, lay then above the limestone, which alone could supply it. To-day we find that the sandstone does contain phosphate. How did it acquire it? The percolation of water has been downward, and away from the sandstone; there has been no upward percolation of water, nor has there been any other means of transferring the calcium-phosphate: and yet the sandstone has received a certain amount from the limestone. The extreme difficulty of accounting for this fact suggests that, after all, perhaps the sandstone did not originally lie above the limestone.

There is no exposure of rocks in the district which shows the contact of sandstone with either basalt or limestone—a contact which would probably throw great light on the question as to whether the sandstone is an original or a secondary formation. But the reasons given above make me of the opinion that it would probably support my view if it did exist.

Rock-phosphate.

Character.—The rock-phosphate is an amorphous nodular deposit, found either in pockets on the upper surface of the limestone, or, where the latter is absent, on top of the underlying glauconite sands. When the limestone is present we always find the masses of rock-phosphate separated from it by thin layers of clay, while thin bands of phosphatic clay are abundant among the hard nodules. The weight of these nodules varies from 1 lb. or 2 lb. up to several tons.

The physical and chemical properties of the rock-phosphate vary greatly: its colour varies from white to dark-yellow; its hardness from 1 to 8; its specific gravity from 2·068 to 2·988; its percentage of contained tribasic calcium-phosphate from 20 (and even lower) to 80 per cent. A detailed description of several varieties will render this more evident:—

a. (H = 6·5, SG = 2·915).—To the eye this variety suggests the appearance of marble; it is white, hard, of dull lustre, and contains grains of quartz and glauconite; it is a rich variety, containing from 65 to 80 per cent. calcium-phosphate—$Ca_3(PO_4)_2$.

b. (H = 8, SG = 2·988).—This is yellow, finely grained, and flint-like; it breaks with a conchoidal fracture, has an enamel-like lustre, and often a banded character; it is high-grade, containing from 70 to 75 per cent. $Ca_3(PO_4)_2$.

c. (H = 5·5, SG = 2·910).—A yellow variety like *b*, but coarser-grained, not flint-like, and never with a banded appearance; it also is of good quality.

d. (H = 6, SG = 2·816).—This is the very siliceous "grit phosphate," which is in fact a sandstone cemented together by lime-phosphate; it often contains enclosed nodules of the *b* variety, and in places is found incrusted with hyalite, a form of opal; it is poor in phosphate, containing only from 20 to 30 per cent. $Ca_3(PO_4)_2$.

e. (H = 1, SG = 2·446).—This is a pure-white, chalky, unctuous variety, rich in phosphate, of which it contains about 75 per cent.

f. (H = 1, SG = 2·068).—This variety can scarcely be termed rock-phosphate, as it is only a finely laminated phosphatic clay which has hardened to a slight extent, and now occurs in irregular seams among the masses of hard rock-phosphate.

The first four are the most common; when they are "burnt" the iron which they contain is converted to ferric oxide, which gives them a pink or reddish colour. Under the microscope the yellow varieties are seen to have no trace of crystalline structure; they are almost opaque in thin sections, a dull-brown colour being transmitted only in the very thinnest places; quartz and glauconite grains occur throughout.

Analyses.—The following table of analyses will show the chemical composition of these phosphates:—

—	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Gangue	9·51	2·80	9·2	7·3	16·0	21·0	6·8	4·5	11·9	2·1	1·5	32·1	1·48	3·90	60·12
Alumina	8·06	6·49	4·2	3·4	5·0	4·1	4·0	2·5	4·9	1·4	2·6	8·0	5·30	6·20	5·79
Iron-oxide														3·28	3·41
Magnesia	0·40	0·85	..	..	..	..	..	..	0·9	..	..	..	0·50	0·65	..
Lime	40·82	46·48	47·7	48·3	42·6	39 9	44·6	49·0	44·4	..	..	..	48·25	45·10	15·61
Alkalis	0·70	0·90	..	..	..	..	..	..	0·7	..	..	..	..	..	..
Combined water ..	1·01	0·02	3·1	3·8	3·4	..	2·5	..	1·7	..	..	..	..	..	..
Moisture	3·81	1·30				1·6	3·5	..	1·1	..	..	..	4·60	2·25	1·15
*Phosphoric acid ..	30·89	35·05	32·1	32·9	30·0	29·0	31·4	32·6	30·2	36·7	34·4	18·0	35·38	33·65	11·39
Carbonic acid ..	3·78	4·80	2·7	3·0	3·0	4·4	3·9	..	2·9	..	..	..	3·20	4·29	3·72
Sulphuric acid ..	0·30	0·34	..	..	..	..	..	..	Trace	..	..	..	†	‡	..
	99·28	99·21	99·0	98·7	100·0	100·0	96·7	88·6	98·7	..	...	..	98·91	99·32	101·19
*Equivalent of $Ca_3(PO_4)_2$	67·44	76·52	69·9	71·6	65·3	63·3	68·7	71·2	65·9	80·2	75·1	39·3	76·59	73·44	25·87

†13 contains trace of chlorine. ‡ 14 contains traces of chlorine and fluorine.

The analysts for the above were: 1 and 2, Millburn Lime and Cement Company; 3, 4, 5, and 6, Professor J. G. Black, Otago University; 7, J. S. Maclaurin, D.Sc., F.G.S., Wellington, New Zealand; 8, W. Mills, Bramford, North Ipswich; 9, J. A. Pond, Auckland, New Zealand; 10, 11, and 12, O. Grothe, Ph.D., Ocaha, Florida, U.S.A.; 13, author, chalky variety (*e*); 14, author, yellow variety (*c*); 15, author, grit variety (*d*).

Iron and Alumina.—The large amount of iron and alumina in this phosphate will probably constitute an objection to it in the eyes of the agriculturist. Alumina, when present in a phosphate, is combined with part of the phosphoric acid, the latter being thus rendered unavailable for assimilation by plants, and for conversion into superphosphate of lime; this happens at Yorke's Peninsula, South Australia,* and in the Lower Greensand, England†: iron has an effect similar to that of alumina. Moreover, the superphosphate produced when iron and alumina are present is usually sticky and claggy.‡ The Clarendon phosphate contains a larger amount of these objectionable iron and aluminum oxides than do those of most other countries, as will be seen from the following table. It is with these foreign phosphates that the New Zealand phosphate must compete, if it is to be exported to any extent.

Locality.	Iron and Alumina. Maximum Percentage.	Minimum Percentage.	Mean.	Authority.
Belgium ..	1·20	0·90	..	Penrose, U.S. Geol. Surv. Bull. 46, p. 106.
North France ..	..	..	3·20	Ditto, p. 41.
Russia ..	3·47	0·32	..	,, p. 46.
South Carolina..	6·00	1·00	..	,, p. 70.
North Carolina..	..	..	0·56	,, p. 72.
Ocean Island ..	..	..	0·46	Danvers Power, "Mineral Industry," vol. x, p. 523.
Pleasant Island	..	..	0·51	Ditto, p. 523.
South Australia	6·26	1·00	..	Brown, Rep. Geol. Surv. S. Aus., 3/2/1902 and 2/7/1902.
North Wales ..	8·86	6·89	..	Penrose, U.S. Geol. Surv. Bull. 46, p. 83.
Upper Greensand (Eng.)	12·11	4·61	..	Ditto, pp. 97, 91.
Lower Greensand	8·82	3·35	..	,, p. 101.
Clarendon ..	9·58	1·40	5·24	

Excess of Lime.—There is another feature of the chemical composition of these phosphates which, possessing a certain theoretical interest, may be noted here. F. Danvers Power,§ in his report on the Ocean and Pleasant Island phosphates, says, "As is always the case, there is an excess of lime (CaO) over the acids present that are capable of combining with it; supposedly, this excess is an organic combination." Whatever

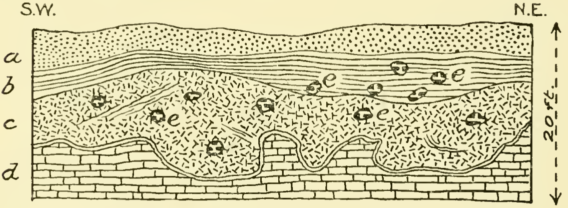
* Brown, Rep. Govt. Geologist South Australia, 3rd February, 1902.
† Penrose, U.S. Geol. Survey Bull. 46, p. 102.
‡ Penrose, U.S. Geol. Survey Bull. 46, p. 83.
§ Danvers Power, "Mineral Industry for 1901," vol. x, p. 533.

the cause of the phenomenon, it is interesting to note that the Clarendon phosphate is similar in this respect to the deposits of Ocean and Pleasant Islands. After making corrections for other bases in the phosphate it is found that the CaO present is always greater than the CaO which would be required to neutralise the acids in the phosphate, thus: Ocean Island, the excess is 6·8 per cent.; Pleasant Island, the excess is 6·8 per cent.; Clarendon No. 1, the excess is 2·4 per cent.; Clarendon No. 2, the excess is 6·1 per cent.; Clarendon No. 13, the excess is 7·8 per cent.; Clarendon No. 14, the excess is 9·4 per cent.

Outcrops in the District.

1. *Williamson's Farm.*—The outcrop has not yet been located, but surface boulders and pebbles are abundant in the fields below the road-line at some distance above Williamson's.

2. *Kiln Point.*—At this, the first outcrop worked, the phosphate rests on the irregular surface of the limestone, the face exposed being about 12 ft. high. The rock is mainly the high-grade white variety, but it is mixed with brown sands and phosphatic green sands and clays, which diminish the average content of calcium-phosphate to such an extent that this outcrop has now been abandoned in favour of the Round Hill quarry. Rock-phosphate is exposed in a trench to the north of the point, where it consists chiefly of the grit variety, mixed with phosphatic clays; mammillary incrustations and cavities lined with phosphorite are common in the trench.



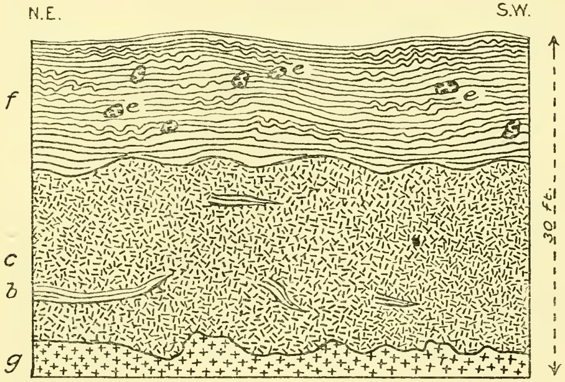
Face of Quarry at Kiln Point.

a. Brown sands. *b.* Green phosphatic sands. *c.* Rock-phosphate. *d.* Limestone. *e.* Basalt-fragments.

A special feature of this outcrop is the presence of fragments of basalt, from 0·5 in. to 4·5 in. in diameter, which are imbedded in the middle of the rock-phosphate. They have the same characters as the basalt which is found a few yards farther up the hill, and have probably slipped down from there. They show clearly that the formation of the rock-phosphate was subsequent to the pouring-out of the basaltic lava which now caps the hills. They indicate, moreover, that the formation was some considerable time after that—in fact, not until the surface features of the district had assumed practically their present form—for not until a hill was formed would basalt-fragments be able to slip down that hill and mingle with limestone and sands lying at a lower level.

3. *Horseshoe Bush.*—Close to the Horseshoe Bush two small outcrops have been exposed, but only a few tons of phosphate have been mined.

4. *Discovery Point.*—It was at this point, opposite the present workings of Round Hill quarry, that the original discovery of the rock-phosphate was made. The phosphate here rests on top of the glauconitic limestone; it has not been mined to any extent.

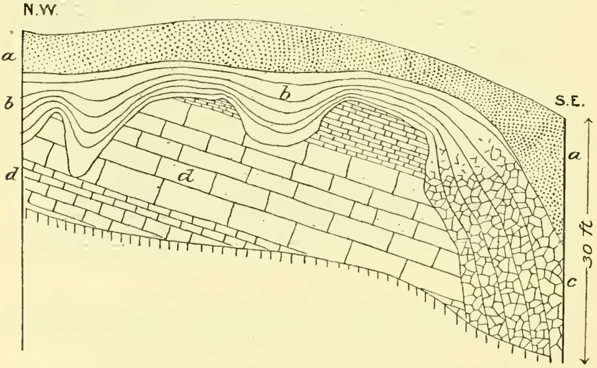


FACE OF QUARRY AT ROUND HILL.

b. Green phosphatic sands. *c.* Rock-phosphate. *e.* Basalt-fragments. *f.* Overburden (clay). *g.* Glauconite sands.

5. *Round Hill Quarry.*—This is now the scene of greatest activity in the district. During 1902 (*i.e.*, during the seven months following the discovery) between 2,000 and 3,000 tons of phosphate were mined from the Kiln Point and Round Hill

quarries,* chiefly from the latter; since then operations have been restricted to the Round Hill workings, but I am unable to quote the amount extracted. The phosphate lies here directly on top of the glauconite sands, the limestone being entirely absent. At the base of the deposit there is a mass of yellow nodules, usually separated from each other by phosphatic green-sands; above this comes an irregularly undulating band of soft clayey phosphate, often containing glauconite; above this again come hard yellow nodules. Irregular small lumps of sandstone often occur amid the phosphate, and large masses of white phosphate, more massive than the yellow nodules, are frequent; incrustations of phosphorite are occasionally found. The workmen often find bones and teeth in the clays and sands among the phosphate; never yet, to my knowledge, have they found any such organic fragment in the centre of the hard rock-phosphate, so that a concretionary origin round an organic nucleus cannot be assigned to it. The bones which are found are in a very decomposed and broken state, and will rarely bear handling; they belong to species of an extinct Cetacean family comprising *Squalodon* and *Zeuglodon*; the teeth are those of sharks, and are also much broken up. Teeth of *Carcharodon auriculatus* and of species of a *Lamna* were recognised from this quarry.



FACE AT WILSON'S QUARRY.

a. Brown sands. *b.* Green phosphatic sands. *c.* Rock-phosphate. *d.* Limestone.

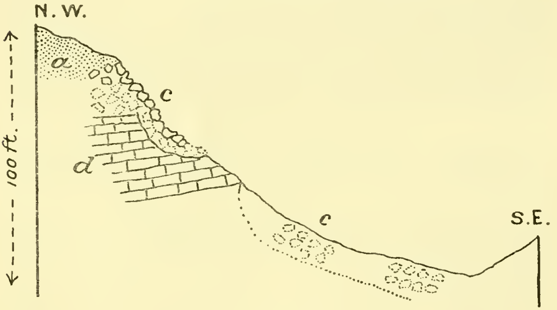
* New Zealand Mines Report for 1902, p. 24.

6. *Wilson's Quarry.*—The phosphate is here very low-grade, and is not worked. It consists of a phosphatic clay, in places 35 ft. high, which contains about 20 per cent. $Ca_3(PO_4)_2$. Desiccation has caused the clay to crack irregularly, and many of the fissures are now being filled up with white incrustations of phosphorite. The deposit rests on the irregular surface of the limestone, and is accompanied by phosphatic greensands.

7. *Kapiti Quarry.*—Phosphate is found here; it is not worked, and its mode of occurrence is not clear.

8. *Strain's Farm.*—Phosphate is reported from here, but was not seen by me.

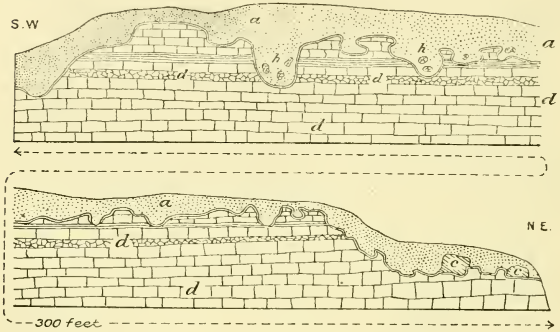
9. *Macdonald's Outcrop.*—Some few tons of phosphate have been mined from here; it rests on the glauconite sands, and a face about 50 ft. long and 10 ft. high has been cleared.



MILLBURN PHOSPHATE-WORKINGS: Section right-angles to face.
a. Brown sands. *c.* Rock-phosphate. *d.* Limestone.

10. *Millburn Company's Phosphate-workings.*—A considerable amount of work has been done here. A great deal of the phosphate is of the grit variety, but the other forms are also found; incrustations of phosphorite are common. The deposit rests on the irregular surface of the limestone; bones and teeth are found in it, among the former being the lower jaw of a Balænid whale. A large surface-slip has taken place, resulting in masses of phosphate sliding down the hillside to a level 50 ft. below: these masses are easily mined, and have been worked to a considerable extent.

11. *Millburn Lime Quarry.*—Two boulders of phosphate occur here, resting on the irregular surface of the limestone. On the spur across the gully, north-west from the quarry, there is a prominent outcrop of phosphate, which so far has not been worked.



FACE AT MILLBURN LIME QUARRY.

a. Brown sands. *c.* Rock-phosphate. *d.* Limestone. *h.* Phosphatic clay nodules.

12. *Campbell's.*—Opposite Sutherland's quarry, on the north bank of a small creek, there is a massive outcrop of rock-phosphate, 20 ft. high, resting on the limestone; it has not yet been worked.

13. *Quill's.*—A few tons of phosphate have been taken from here, but apparently there is not much of it.

14. *J. Gray's.*—This has been worked to a slight extent, but the phosphate, which here rests on glauconite sands, is low-grade, patchy, and composed mostly of grit phosphate and clays.

ORIGIN OF THE ROCK-PHOSPHATES.

Several theories have offered themselves as explaining the origin of these deposits: they may be summed up as follows:—

(1.) That the boulders were transported to their present position from a distance, by an agency such as running water.

(2.) That they were formed *in situ*, as the result of concretionary action around some nucleus.

(3.) That they were formed *in situ* by deposition of phosphoric acid (P_2O_5) from ascending waters.

(4.) That they were formed *in situ* by deposition of P_2O_5 from descending waters which derived their P_2O_5 from the basalt.

(5.) That they were formed *in situ* by deposition of P_2O_5 from percolating waters which derived their P_2O_5 from the limestone.

(6.) That they were formed *in situ* by the concentration of the phosphatic contents of the limestone—a process due to ordinary weathering and the action of meteoric waters.

(7.) That they were formed by the combined action of the methods outlined in the last two theories. This combination theory is the one I see most reason to support.

1. *Transportation Theory.* — This is extremely improbable. The phosphate boulders are separated from the limestone and from each other by bands of phosphatic clay and by layers of sand. Running water would most probably have been the agency by which the boulders were transported, if they were transported at all. It is scarcely possible that a violent stream capable of moving a boulder of 2 or 3 tons weight would deposit that boulder on a thin stratum of clay or sand. Much more likely is it that the stream would sweep away clay and sand and deposit the boulders on the bare surface of the limestone. I have not observed a single instance of this direct contact of limestone and rock-phosphate; I have always found a layer of clay or sand between the two. Moreover, the presence of basalt-fragments imbedded in the phosphate at Kiln Point is sufficient to disprove the theory, for it shows that the rock-phosphate was formed after, and probably a long time after, the extrusion of the basalt.

2. *Concretionary Theory.*—It is not at all probable that the rock-phosphate was formed by concretionary action around some nucleus, in a manner analogous to the coprolites of the Upper and Lower Greensands of England. None of the Clarendon nodules have been found to contain organic nuclei, and the sharks' teeth and other organic fragments at Round Hill, &c., always lie on the clays, and not imbedded in the hard nodules.

3. *Ascension Theory.* — The occurrence of phosphorite and perhaps staffelite as stalactites and as incrustations on the walls of cavities suggests that an aqueous solution of phosphoric acid must have played, and must still be playing, some part in the formation of the phosphate. Could this solution have risen from below? No, it could not, for in many places the phosphate rests on the surface of unaltered limestone; had the solution risen from below it would first have acted on the lower layers of limestone, converting the calcium-carbonate to

calcium-phosphate, and the process would then have extended itself upwards. As we find the phosphate above and the carbonate below, it is tolerably certain that the process is extending itself downward, and is due to descending solutions.

4. *Basalt Theory.*—That the deposits were formed *in situ* by the deposition of P_2O_5 from descending waters which derived their P_2O_5 from the basalt. I do not think it possible that the overlying basalt could have supplied the P_2O_5 necessary. No phosphorus-bearing mineral was detected in the microscopic examination, and micro-chemical tests likewise failed to reveal the presence of any such mineral.

5. *Limestone Theory.*—That the deposits were formed by the deposition of P_2O_5 from percolating waters which derived their P_2O_5 from the limestone. It is certain that the phosphoric acid was derived from the limestone. We have seen that organic remains rich in phosphorus are found in the latter, and that, moreover, a small amount of phosphate is distributed throughout its mass. I think that a deposition from waters is in part responsible for the formation of the phosphate, but that it is subordinate and subsequent to a concentrating action.

6. *Concentration Theory.*—That the deposits were formed by the concentration of the phosphatic contents of the limestone, by the weathering action of waters containing carbonic and perhaps other organic acids, which dissolved out the calcium-carbonate of the limestone, but left behind the much less soluble calcium-phosphate.

7. *Combination Theory.*—That the process just outlined was followed by the deposition of P_2O_5 from percolating waters which had leached out their P_2O_5 from the limestone. The mode of weathering of the limestone at the Millburn quarry lends a great amount of support to this view. The surface of the limestone is carved out into a number of deep "guts," leaving lofty pinnacles and overhanging shelves of limestone—an appearance which at first suggests a striking unconformity with the brown sands which fill the depressions. The sculpturing, however, is almost wholly if not entirely due to chemical erosion.

On the outer parts of the pinnacles, where exposed to wind and rain, the limestone has in many places weathered to a crumbly brownish sandstone, containing comparatively a small percentage of $CaCO_3$. Along the laminæ the weathering has progressed more quickly. Isolated "floaters" of limestone are found in the middle of the brown sands; they are blocks of limestone which have offered great resistance to the weathering process, and are now entirely surrounded by clays and sands, in the midst of which, still horizontal, they seem to float. A sample was taken from the interior of one of these floaters, where it was least weathered ; it was partially analysed, as also was a sample of absolutely fresh limestone of the same band (H). The analyses gave :—

	Fresh Limestone.	"Floater."
Gangue (mostly quartz) ..	5·50	27·09
*Phosphoric acid	0·15	0·22
Not determined	94·35	72·69
	100·00	100·00
*Equivalent of $Ca_3(PO_4)_2$ ..	0·33	0·48

These analyses prove, then, (1) that the limestone H contains when fresh a small amount of phosphoric acid disseminated through its mass ; (2) that the ordinary process of weathering, which carries away the calcium-carbonate in solution, does not carry away the calcium-phosphate to an equal extent, so that the latter tends to concentrate in the residue.

The "Gut" at Millburn.—Brown and green sands and clays fill the hollow between two pinnacles, and protect the limestone surface from the atmosphere, but not from percolating waters. In the deepest central "gut" the limestone is found to have a thin veneer, about 0·75 in. thick, of a pulverulent weathered limestone (C_1). Outside this veneer comes 6 in. of a green glauconitic and phosphatic sand (C_2), the whole of this layer being laminated with fine streaks of not yet completely weathered limestone, arranged rudely parallel to the present limestone surface. Outside C_2 is found a varying thickness of yellow-green very sandy clays (C_3), laminated parallel to the surface of the limestone, the laminæ being from 0·06 in. to 0·25 in. apart, and composed of alternating green and yellow bands. These clays line the limestone wherever the latter is protected from the atmosphere—on pinnacles, in hollows, and on the under-side of projecting ledges alike. A tough yellow richly phosphatic clay (C_4) is found in the midst of the yellow-green clays ; it is sometimes in bands, more often in irregular patches and nodules.

The following analyses will show the manner in which the concentrating action has taken place. The limestone has been deprived of its $CaCO_3$; the quartz, glauconite, and to a great extent the lime-phosphate, being insoluble, have been left behind and concentrated to form C_1 and then C_2. Then the C_2 has been separated into two parts, the lime-phosphate tending to segregate into the clayey nodules C_4, surrounded by yellow-green clayey sand C_3. This differential action is due to water, which has acted by dissolving and then reprecipitating some of the lime-phosphate.

—	Veneer on the Limestone. C_1.	Glauconite Sands. C_2.	Yellow-green Clayey Sand. C_3.	Tough Yellow Segregations. C_4.
Silica ..	9·24	59·08	74·15	44·92
Fe_2O_3 and Al_2O_3	3·00	18·05	15·10	21·72
CaO ..	44·29	6·72	2·28	12·09
H_2O ..	14·80	10·20	7·70	13·50
*P_2O_5 ..	0·77	5·65	1·22	7·75
CO_2 ..	29·74	..	..	..
	101·84	100·16	100·45	99·98
*Equivalent of $Ca_3(PO_4)_2$	1·68	12·32	2·66	16·90

The above analyses show that a concentration has taken place. If we change their form slightly they show us also that the calcium-phosphate is not absolutely insoluble, and that even in the process of concentration some of it has been carried away in solution. In the concentration and solution it is safe to assume that the silica (SiO_2) is not carried away nor affected by any chemical action. We are thus enabled to recalculate the analyses on the basis of constant SiO_2 : *e.g.*, if a body (x) contains 1 part per 100 of an unchangeable substance (m), and a quantity of it is partly dissolved away, resulting in a product (y) which contains 5 parts per 100 of m, then it is clear that the product y results from 5 times its weight of the original x. On recalculating thus from the analyses we find that 186 parts of C_1 have weathered to 29 parts of C_2, which have differentiated into 14 parts C_3 and 15 parts C_4. The following table gives the amounts of the constituents of each of these products :—

—	186 Parts C_1 ontaining	change to 29 Parts C_2 containing	which split into 14 Parts C_3 containing	and 15 Parts C_4 containing	the total of C_3 and C_4 containing
SiO_2 ..	17·11	17·11	10·37	6·74	17·11
Al_2O_3 and Fe_2O_3	5·60	5·36	2·10	3·25	5·35
CaO ..	82·48	2·03	0·28	1·81	2·09
P_2O_5 ..	1·45	1·72	0·17	1·16	1·33
CO_2 ..	55·10	..	..	..	..
H_2O ..	24·26	2·78	1·08	2·04	3·12
	186·00	29·00	14·00	15·00	29·00

The C_1 column does not tally exactly with the results from the other columns, and this is probably due to errors in the chemical analysis. It must be remembered also that any errors that do occur in the analysis are almost doubled in the case of C_1, while they are diminished in the case of the others, roughly in the proportion of 3 to 1 and 6 to 1 respectively. Noticing the other columns only, we see that the iron and alumina, like the silica, are not removed by the weathering process, 5·35 resulting from 5·36. The amount of moisture (H_2O) is of no importance in this inquiry, though apparently it also does not change much. P_2O_5, however, has been abstracted, 1·33 resulting from 1·72. This difference is too great to be merely due to error in analysis. It is clear, then, that phosphoric acid has been dissolved out from the clays; it joins the downward circulation, and is redeposited where conditions are favourable.

Stages of Process.—The amount of action that has taken place in this gut at Millburn is small, but the full sequence of operations is clearly seen. At Wilson's quarry the process is more advanced, and has resulted in the formation of a large quantity of phosphatic clays, which are now being cemented together by the redeposition of the phosphoric acid as lime-phosphate in the cracks which traverse the clay. The process has reached its final stage at the Round Hill quarry, where all the calcium-carbonate of the limestone has been dissolved away, its place being now occupied by a mass of rock-phosphate. The final stage has likewise been reached on the right-hand side of the limestone quarry at Millburn, where now two boulders of hard rock-phosphate, in the middle of the brown sands, rest on the chemically eroded surface of the limestone.

Objections.—The objections which may be advanced against this theory are, I think, the following:—

1. That the process outlined cannot account for large quantities of rock-phosphate such as are found at Round Hill. To explain such a large occurrence it is only necessary to suppose that the original limestone at that point contained a very great number of organic remains, such as bones, &c., and this supposition is upheld by the occurrence of numerous bone-fragments among the phosphate at Round Hill.

2. That the rock-phosphate ought to be always accompanied by brown sands or sandstone. As a matter of fact it usually is, though it is not necessary that it should be so; the original limestone now eroded away may at one place have been rich in phosphate, poor in silica: this would produce a rock-phosphate with very little sandstone about. Conversely, the original limestone at another place may have been rich in silica, poor in or destitute

of phosphate: this would produce a sandstone with no rock-phosphate in its neighbourhood.

Conclusions.—My conclusion, then, is that the rock-phosphate has been formed by the action of meteoric waters slowly weathering away a limestone containing a small amount of lime-phosphate, leaving most of the latter behind, but dissolving some and reprecipitating it where conditions were favourable. Where the limestone originally contained a large amount of lime-phosphate, owing to abundance of vertebrate remains, there the rock-phosphate will be found in greatest abundance. Where the limestone originally contained practically no phosphate, there its weathering will give rise to no deposits of rock-phosphate. The limestone owes its contained lime-phosphate to the presence of organic remains, especially those of vertebrate animals; the distribution of these is of an irregular nature; the weathering of such a limestone ought to give rise to irregularly distributed deposits of rock-phosphate: this is what we find.

Professor Park,* in his account of the Clarendon phosphates, does not hazard any opinion as to how these particular deposits originated. He says, "The formation of phosphate-deposits is generally believed to have been due to the leaching or lixiviation of phosphate-bearing rocks by waters containing carbonic and other organic acids, followed by the subsequent concentration of the phosphate under favourable conditions. In some cases they deposited their calcium-phosphate in caverns formed in limestone or calcareous sandstone, and the subsequent removal by solution of the walls of the caverns, either wholly or partially, left the phosphate in the remaining sands."

Similar Theories Abroad.—The theory advanced above resembles the theories which have been advanced to explain the origin of other deposits of lime-phosphate. Accounting for the phosphatic beds near Mons, Belgium, F. L. Cornet† says, "These phosphates have been formed from the concentration of phosphatic matter, originally disseminated in the lime-carbonate, the concentration having been effected by the action of water containing carbonic acid."

C. W. Hayes,‡ accounting for the white phosphate of Tennessee, sums up thus: "The original lime-phosphate . . . accumulated with other sediments, either segregated in beds or disseminated through limestones and shales. . . These were attacked by percolating surface waters which contained carbonic and other organic acids, and which dissolved the $CaCO_3$,

* Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 400.

† Cornet, Quart. Journ. Geol. Soc., vol. xlii (1886), p. 337.

‡ Hayes, U.S. Geol. Surv., 17th Ann. Rep., part ii, p. 547; 21st Ann. Rep., part iii, p. 479.

and in less quantity the $Ca_3(PO_4)_2$. The carbonate was carried away; the phosphate was redeposited, the form of the deposits being modified by local conditions."

Comparison with Other Deposits.—The phosphates of South Carolina* consist of waterworn nodules, much bored by marine animals; phosphatic casts of the interior of shells are abundant. The North Carolina phosphates† are in part like the South Carolina deposits, but there is also a phosphatic conglomerate with teeth, bones, nodules, and quartz pebbles all well rolled and rounded and cemented together. The Alabama deposits‡ are, like those of South Carolina, composed of shells, phosphatic nodules, shell-casts, and fossils, all much worn and broken, usually flat in form, and more phosphatized on one side than the other. The nodular depositis of Florida§ rest on the uneven surface of a calcareous rock, being associated with shells and sands. At one of the quarries the soft calcareous rock gradually blends at a depth of 3 ft. or 4 ft. into a massive compact phosphate rock, similar in appearance to the phosphatic fragments above, except that it is a solid mass; it is probably the ledge whence the fragments were derived, the phosphatic pebbles and the sand being due to deposition on the eroded surface of the calcareous rock. Carnot,‖ however, holds a different opinion of these Florida deposits. He considers them of concretionary origin; he emphasizes the high percentage of CaF_2, and argues that the concretionary action is due to the concentrating action of salt water. The phosphates of the West Indies, at Aruba and Sombrero,¶ and also those of Ocean and Pleasant Islands,** were originally coral limestones, now converted into phosphate by the percolation of waters containing phosphoric acid derived from the overlying deposits of bird-guano. The deposits of Ottawa (Canada),†† and of many other localities, occur as veins of apatite in very old igneous rocks, mostly of Archæan age. The phosphates of Wales‡‡ consist of apatite veins and of amorphous nodular deposits; the latter contain numerous remains of animal life, and are due to the phosphatization of a calcareous bed. In England§§ the de-

* Penrose, U.S. Geol. Surv. Bull. 46, p. 61.

† *Ibid.*, p. 70.

‡ *Ibid.*, p. 75.

§ *Ibid.*, p. 78.

‖ Carnot, "Annales des Mines" (1896), vol. x, p. 228.

¶ Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 401.

** Danvers Power, "Mineral Industry for 1901," vol. x, p. 533.

†† Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 400.

‡‡ Penrose, U.S. Geol. Surv. Bull. 46, p. 80.

§§ Sollas, Quart. Journ. Geol. Soc. (1872), vol. xxviii, pp. 397–400; Fisher, Quart. Journ. Geol. Soc. (1873), vol. xxix, p. 55.

posits consist almost entirely of nodules which are composed of phosphatized animal matter, while those in the neighbourhood of Taplow and Lewes* are phosphatic chalks of sedimentary origin. Those of the Somme in France† are also chalk-deposits, the phosphate being "a sedimentary chalk derived from the disintegration of a vast granitic phosphatic continent." Near Mons, in Belgium,‡ the phosphate-deposits are also with Cretaceous chalk. They consist of a coarse-grained rock formed of a mixture of grains of calcite and small-sized pebbles of phosphate ; they are due to a concentration by water of a limestone originally containing a small amount of lime-phosphate. In Algeria and Tunis§ the phosphates occur in nodules in marl or as phosphatic limestone.

Though not precisely similar to any other known deposit, the Clarendon-Millburn phosphate bears greatest resemblance to those of Florida, U.S.A. The local phosphate, however, contains only a trace of fluorine, and has no shell-traces ; the calcareous rock does not become highly phosphatic in depth ; and the mode of origin is different from either of the two theories advanced to explain the Florida deposits. In all these points it differs from the Florida phosphate, so that, after all, the similarity is not so very marked.

Mining and Treatment.—At Round Hill quarry the phosphate is blasted out with gelignite, the holes for the charges being very difficult to bore, on account of the hard nature of the rock. Very little hand-sorting takes place in the quarry, the rock being immediately loaded into trucks or "boxes" and drawn to the burning-ground, where it is built up with broadleaf timber into large piles. The burning extends throughout several days, and deprives the rock of its moisture, thus rendering it brittle so that it can be more easily pulverised, and also effecting a small saving in the cost of its railway carriage to Burnside, a few miles south of Dunedin, where some of it is treated with a spray of dilute sulphuric acid to partly convert it into superphosphate of lime. This chemically treated phosphate commands a higher price than the phosphate which has not been so treated. The former is more rapid in its effect on the crops, as the superphosphate is at once ready for assimilation by plants, while the phosphate in the crude, unsprayed rock has

* Teall, Proc. Geol. Assoc., vol. xvi, p. 369.

† Henri Laone, "Sur l'Origine des Phosphates de Chaux de la Somme" (1903).

‡ Penrose, U.S. Geol. Surv Bull. 46, p. 105. Cornet, Quart. Journ. Geol. Soc. (1886), vol. xlii, p. 325.

§ Park, Trans. N.Z. Inst. (1902), vol. xxxv, p. 400.

to be slowly converted by the action of humic and other acids before it is available for absorption.

Prospects of the Industry.—The amount of rock-phosphate occurring in the district cannot be accurately estimated at present. As the original phosphate to which it owes its origin was probably irregular in its distribution, so we must expect our deposits of rock-phosphate to be irregularly distributed along the outcrop of limestone. The question whether the phosphate will occur between the already located outcrops cannot at present receive a satisfactory answer; in some places it will, in others it will not; the position of these respective places can only be determined by further prospecting. From its origin it follows that the phosphate will not extend inwards under the protecting basalt cap; and for this reason also it follows that there is a greater chance of its occurring in quantity under a gently sloping surface than under a steep one, for in the former case a much greater width of limestone has been exposed and subjected to the actions which lead to the formation of the phosphate. Until prospecting affords more information about the extension of the outcrops it would be useless to attempt an estimate of the quantity in sight.

The sale of the phosphate will, in my opinion, be confined to New Zealand. To compete in foreign markets, high-grade rock-phosphate must contain at least 77 per cent. of calcium-phosphate—$Ca_3(PO_4)_2$—and its amount of alumina and iron must be low. A reference to the list of analyses in this paper will show that it will be difficult to guarantee that any large quantity of the phosphate fulfils these requirements. Other countries, moreover, owing to their more favourable geographical position, are better enabled to command the foreign markets. In New Zealand the phosphate will have to compete against the imported guanos, and against agricultural limes produced by the burning of limestone; against these it is capable of holding its own, and of making progress.

Other districts in New Zealand may also contain unrecognised deposits of phosphate of lime. The discovery at Clarendon was followed by the discovery of a smaller deposit at Enfield, near Oamaru, but we have not heard much about this. Limestone occurs in quantity throughout New Zealand, chiefly in the South Island; and its surface, especially where eroded to any great extent, should be carefully examined for rock-phosphate. The phosphate had been overlooked at Clarendon for many years, and it may still be overlooked in some other locality. It is easily mistaken for limestone, flint, &c., according to the variety met with. It would be well worth while to submit to qualitative chemical analysis any peculiar-looking rock-fragment found in the neighbourhood of limestone or of glauconitic sands.

In conclusion, I should like to express my gratitude to Mr. R. Ewing, of the Clarendon Phosphate Company, and to Mr. F. Oakden, of the Millburn Lime and Cement Company, for their kindness in allowing me to make use of several of their analyses of rock-phosphate, and for their unvarying courtesy during the examination of the deposits. To Professor Park for his lucid and instructive report, to Dr. Marshall, Dr. Benham, Mr. A. Hamilton, and Mr. D. B. Waters for their valuable advice and assistance during the preparation of this paper, my warmest thanks are due.

EXPLANATION OF PLATES IV–VIII.

Plate IV.

Fig. 1. *Squalodon grateloupi* (?): *a*, premolar, showing enamel; *b*, crown of worn molar; *c*, section of *b* close to top of crown; *d*, section of *b* nearer the fangs; *e* and *f*, molars.
Fig. 2. Balænoid whale, dentory: *a*, view from above; *b*, view along jaw.
Fig. 3. *Magellania marshalli*: *a*, both valves; *b*, side view.

Plates V–VII.

Fig. 1. Glauconitic limestone (B).
Fig. 2. Glauconitic limestone.
Fig. 3. Basalt, Stony Knob, crossed nicols; × 80 dias.
Fig. 4. Basalt, Williamson's, crossed nicols; × 80 dias.
Fig. 5. Basalt, Cemetery Hill, crossed nicols; × 80 dias.
Fig. 6. Sandstone; × 80 dias.

Plate VIII.

Geological map of Clarendon-Millburn district, with ideal section.

Art. LIII.—*The Gem Gravels of Kakanui; with Remarks on the Geology of the District.*

By J. Allan Thomson, B.Sc., Rhodes Scholar.

Communicated by Geo. M. Thomson.

[*Read before the Otago Institute, 14th November,* 1905.]

There have long been in the collections of the Otago Museum and of the Otago School of Mines specimens of sands from Kakanui, labelled "gem sands." The late Professor Ulrich, Director of the Otago School of Mines, was of opinion that gems would some day be found at Kakanui, evidently being struck by the association of minerals which these sands contained. Their investigation seems desirable both from a theoretical and a practical point of view. In the investigation of their matrix there has been occasion to make some general remarks on the geology of the district. For the purposes of more convenient reference hereafter, it has been thought desirable to keep detailed descriptions of the collected fossils for a separate paper.

Kakanui (Maori; "large kaka") is the name of a range of mountains, a river, and a township, all situated in the north-east corner of Otago. The name has been applied by Captain Hutton to the upper part of the Wanaka system, of early Palæozoic age, typically developed in the Kakanui Mountains. The Kakanui River derives its gravels largely from these and younger submetamorphic rocks. The country between the river and the sea is composed mostly of the Oamaru formation of early Tertiary age. It may be roughly described as consisting inland of conglomerates overlaid by limestones, near the coast of ash-beds capped by limestones.

PREVIOUS OBSERVERS.

There appears to be no reference, in the many geological papers dealing with the neighbourhood, bearing directly on the "gem gravels" as such. The Oamaru district is the typical locality for the Oamaru system in New Zealand geology, and has been frequently explored by geologists, chiefly for the sake of determining the age of the system (which by Sir James Hector is included in his Cretaceo-tertiary system, and by Captain Hutton is ascribed to Oligocene). The papers on this subject occur mostly in the "Reports of the Geological Survey of New Zealand" and the "Transactions of the New Zealand Institute." These will be referred to in due place.

Mr. Mantell, the first geologist to visit the district, noted the "volcanic grit" of Kakanui, which has proved to be the matrix of the "gem sands." His observations on these minerals seem to have been entirely overlooked by all subsequent observers, although his paper is frequently referred to in discussions on the age of the rocks. The following is the paragraph referred to: "The volcanic grit of Kakanui . . . contains a great variety of crystalline volcanic products, as hornblende, augite, garnets, &c." *

After the fullest inquiries from residents in the district, and personal examination of many localities, both in the valleys of the Kakanui River and its tributary the Waiareka, it has been found that there are three distinct occurrences of stones that may be possibly of value as gems. The first is of sapphire,

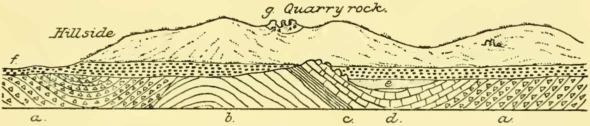
* Mantell, Quart. Journ. Geol. Soc., 1850, p. 325.

identified as such by Professor Ulrich. Mr. Charles Reid, of Windsor, has cut some specimens of these. They were obtained from a gold-miner who worked in Slaty Creek, a tributary of the Kakanui, which enters it some fifteen miles from its mouth. A superficial search revealed no indication of them in the gravels of this stream. The stones are of fair size, but of poor colour. The second mineral is of a jasperoid nature. It has been traced to Red Hill, near Elderslie, in the property of Mr. Menlove. Green, yellow, and red bands may be obtained, and no doubt polished ornaments might be made of them. The mineral seems to form a large dyke, but more work is necessary on this point. The third occurrence, the "gem gravels" proper, were found to occur chiefly on the beaches south of Kakanui Heads. A recent bed of marine gravel covers large areas of land, and the "gem sands" may be obtained by panning off this gravel. They have been found as far north as Oamaru Cape. No trace of them has been found up the Kakanui or Waiareka Rivers. These sands are similar to the Museum specimens, and may now be briefly described. Besides pebbles (quartz), they contain small cleavage fragments of hornblende and feldspar, clear green minerals (presumably pyroxenes or amphiboles), red minerals (presumably garnets); the two latter minerals being angular and fractured, but showing no crystalline form. On the beach between this stream and Kakanui South Head the sea has concentrated the sands so that they consist almost entirely of garnet and magnetite, forming a thin layer on the top of the ordinary beach sand in a similar manner to the black sands (magnetite) occurring at many places on the east coast of Otago. The beach is periodically worked by a gold-miner, who scrapes off the top layer and washes it in a cradle for gold. It was believed by many of the residents of the district that occasionally rubies were obtained with the gold, and that they fetched a good price. The matrix was found to be a volcanic breccia occurring both on the North and South Head at the mouth of the Kakanui River. All the minerals of the "gem sands" were found in it, with the exception of the magnetite and quartz. These, however, are of such universal occurrence on the east coast of Otago that it is unnecessary to specially consider them here. A general description of the breccia and its relations is given. Detailed accounts of the minerals and fossils are withheld till further investigation has been made.

General Occurrence.

The breccia, for convenience called "mineral breccia," occurs at four or five separated points in the neighbourhood of Kakanui Township. On the North Head it is found for about half a mile on the sea-shore, forming low cliffs capped with gravel, and generally forming a beach of marine denudation for many feet seawards from the cliffs. Proceeding northwards on the beach it is seen to be underlaid unconformably by another volcanic breccia carrying no large crystals, for convenience called "barren breccia." The latter forms the cliffs for about three-quarters of a mile, and then gives way to a conformably overlying very fine tuff, full of cleavage flakes of biotite. The "barren breccia" in its uppermost layer is fossiliferous, having apparently been covered with a coral reef. The fine tuff is only 15 ft. thick, and is overlaid conformably by a limestone which forms the cliffs on the beach for the next half-mile. It is overlaid conformably by a glauconitic greensand, and the whole is covered unconformably by thick beds of gravel and clay.

Further north the limestone gives place, on the cliffs, to the "mineral breccia," which underlies it conformably, and this forms the cliffs for half a mile and then dips under the more recent beds of clay and gravel which form the Awamoa beach and stretch to Oamaru Cape.

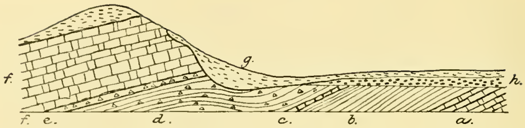


I. DIAGRAMMATIC SECTION AND SKETCH, NORTH HEAD, KAKANUI.

a. Mineral breccia. *b.* Barren breccia. *c.* Fine micaceous tuff. *d.* Limestone. *e.* Greensand. *f.* Gravel. *g.* Quarry limestone.

The "mineral breccia" is also exposed on the west side of the hill forming the North Head, on cliffs near the Waiareka River. Here its relations are not clearly seen, as there is a slide between it and the "barren breccia" on the south, and it is lost under clay to the north. There is also an exposure of the "mineral breccia" about two miles north of Kakanui in a road-cutting (not shown in map); it is overlaid conformably by limestone.

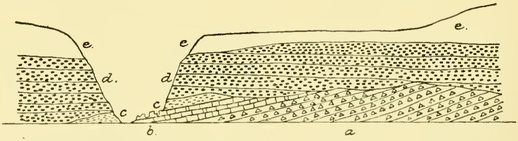
On the South Head there are two exposures of breccia bearing the minerals, but their occurrence is somewhat different. On the cliffs exposed on the river-bank on the south shore the following section occurs :—



II. Section at Cliff on River-bank, South Head, Kakanui.
a. Limestone. *b.* Marl. *c.* Coralline limestone. *d.* Tuffs and breccia. *e.* Hard cap of breccia. *f.* Limestone. *g.* Clay. *h.* Gravel.

A limestone of unknown thickness forms the base; this is covered conformably by a marl or calcareous mud, 26 ft. thick, the upper 6 in. being coralline limestone; then follows 60 ft. of rather fine volcanic tuff containing small cleavage fragments of hornblende, the top layer of 1 ft. being set in crystalline calcite, rather hard, and containing most of the minerals found elsewhere in the breccia. This is covered conformably by at least 40 ft. of limestone, containing many fossils. Clay then forms the cliffs to the mouth of the river. An isolated exposure of limestone occurs just at the river-mouth, its relations being obscured by gravel and an artificial breakwater erected there.

A few yards further on, towards the east, the "mineral breccia" occurs again, and forms the cliffs right round the South Head for about three-quarters of a mile. It contains fossils in its upper layers, and going southwards disappears conformably under a limestone 12 ft. thick. This limestone is covered conformably by a glauconitic greensand, and then gravel forms the cliffs for a mile to the south.

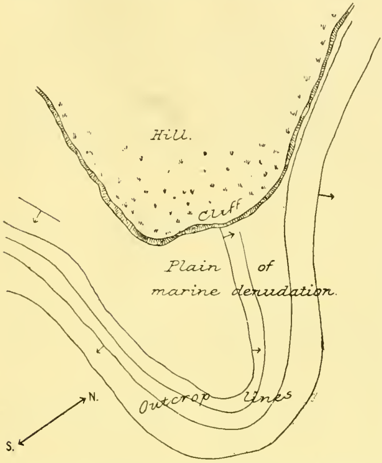


III. On Kakanui South Head. (Distance, ¼ mile.)
a. Mineral breccia. *b.* Limestone. *c.* Greensand. *d.* Gravel. *e.* Clay.

A bluish clay forms the beach for this mile to the south, but does not form cliffs, being only a few feet above sea-level. Its actual contact with the greensand cannot be seen.

The dips of the breccia and the associated rocks vary very rapidly from place to place. At the south end of the North

Head the breccia forms a small anticline, or, rather, elongated dome, as can be seen by tracing the outcrop-lines exposed on the beach.



IV. SKETCH-PLAN OF OUTCROPS OF MINERAL BRECCIA ON THE BEACH, NORTH HEAD, KAKANUI, SHOWING PERICLINAL FOLD.

The breccia is very calcareous and is roughly bedded, suggesting a submarine origin. The size of the included minerals diminishes on proceeding from the axis of the anticline outwards. The following are the largest dimensions of the rocks and minerals exposed here (the two dimensions refer to the two largest in cross-section exposed on the surface of the breccia): Hornblende, 100 mm. by 75 mm.; black augite, 115 mm. by 90 mm.; feldspar, 70 mm. by 40 mm.; garnet, 12 mm. by 10 mm.; green augite, 4 mm. by 5 mm.; basalt inclusions, 25 mm. by 30 mm.; holocrystalline inclusions, 75 mm. by 40 mm.

The thickness of the breccia is rather difficult to determine, but at least 100 yards across the strike is exposed here, which at an average dip of 26° gives a minimum thickness of 130 ft. Further north, along the beach, the dip changes to the opposite direction, showing evidently a synclinal curve. The "barren breccia" also varies considerably in dip, and appears to form an anticline. It is slightly faulted at one place, the displacement being 18 in. to the northwards, and the hade of the fault 60° N. Near the fault is a fissure, filled evidently from above with the materials that form the "mineral breccia"; this filling, withstanding erosion a little better than the "barren breccia," stands out like a dyke. Similar vertical cracks in a tuff at Oamaru are filled with limestone, and at first sight seem to be vertical beds of limestone. The "barren breccia" becomes flatter to the northwards in its upper layers, the dip being 14° at its contact with the fine tuff. The top layer, as stated, is fossiliferous, and appears to have formed the sea-bottom for a sufficient time to permit of a growth of corals.

The chief fossils found here were: Corals—*Flabellum circulare* and other species; *Trochocyathus*, sp.; *Deltocyathus*, sp.; *Amphihelia intricata*; and *Graphularia*, sp. Brachiopods—*Magellania lenticularis* and *M. sinuata*; *Liothyrina*, n. sp.; *Notothyris suessi*; *Terebratella gualteri*; and *Rhynconella squamosa*. Scaphopods—*Dentalium mantelli*. Gasteropods—*Scalaria brownii*; *Siphonalia nodosa*; *Mitra*, sp.; *Gibbula*, sp.; *Turbo*, n. sp.; *Natica*, sp. Lamellibranchs—*Cardita*, n. sp.; and *Pecten sectus*. Cephalopods—*Nautilus*, sp.

The fine micaceous tuffs are poor in fossils, and apparently represent a period during which the ocean-floor was being covered with fine detritus from some neighbouring volcano. The "mineral breccia" contains very little mica; none was found on the sea side of the North Head, and but little on the side next the river. More was found on the South Head in both exposures, but the small amount renders it improbable that these tuffs could have come from the eruptions causing the "mineral breccia."

The limestone overlying the micaceous tuff is, on the beach, poor in shells, being made up largely, as microscopic sections show, of *Foraminifera* and *Bryozoa*. The following genera occur: *Textularia*, *Rotalia*, *Nummulina*, and *Globigerina*.

On the top of the hill forming the North Head, however, a limestone of a different nature, but evidently stratigraphically the same, occurs. It appears to be composed almost entirely of Brachiopod shells, the shells themselves and the spaces between them, however, being filled with the same genera of *Foraminifera* and *Bryozoa* as occur on the beach limestone. It is thus referred to in the Geological Survey Reports (1883, p. 63) by Mr. McKay: "*Kakanui Limestone:* This forms an isolated hill near the Township of Kakanui. The limestone is full of shells, mostly *Brachiopoda*, and thus differs greatly from the ordinary Ototara stone, which is usually poor in such forms. In former reports it was referred to as a Tertiary rock, but closer examination and a large series of fossils collected show it to belong to the lower part of the Ototara stone. The *Brachiopoda* collected in great part belong to *Terebratula*, *Terebratulina*, and peculiar forms of *Terebratella* not found in New Zealand Tertiary rocks."

The limestone here appears to be slightly more crystalline than in other parts, and breaks more readily across the middle of the Brachiopod shells, thus exposing the brachial arms and allowing of certain determination of the genera. Besides this, in the blasting to which the stone is subjected in quarrying, the matter inside and around the shells is shattered, and allows the arms to be exposed by picking. The following fossils were obtained, bearing out Mr. McKay's reference to the genera: *Liothyrina* (*Terebratula*), n. sp.; *Notothyris* (*Terebratulina*) *suessi; Magellania lenticularis; Rhynconella squamosa; Terebratella*, n. sp.; *Pecten sectus; Pecten hutchinsoni; Ostrea*, sp.; *Pleurotomaria tertiaria;* and *Aturia australis.* This limestone, from its pure nature and hardness, is well adapted for burning for lime, and is used for that purpose. On the beach it is softer and contains more impurities of the nature of volcanic-ash inclusions.

The limestone on the beach has at the south a dip in a northerly direction, but it becomes flatter to the north and then dips to the south, thus forming a syncline. It is covered, wherever marine denudation has not denuded it, with a layer about 6 ft. thick of glauconitic greensand containing many fossils. The following were obtained: *Isis*, n. sp.; *Graphularia*, sp.; *Magellania sinuata; Turitella*, sp.; and *Fusus*, sp. (casts); *Dentalium mantelli; Pecten hutchinsoni;* numerous echinoid spines, and sharks' teeth. The limestone is underlain to the north by the "mineral breccia," which is here finer than on the first exposure.

The general relation of the foregoing section is seen in the diagrammatic section (Section I) on p. 485.

Captain Hutton, in a paper on the "Geology of North-east Otago,"* refers thus to these rocks: "*Kakanui Volcano:* The Kakanui River runs into the sea between two low hills formed of scoriaceous sandstone overlain by the Ototara limestone, here generally more compact than usual. The sandstones of the northern hill form a periclinal curve, which extends across the river so as to include the rocks seen in the river-bed between the bridge and the sea." On comparing the sections it will be seen that the folding is rather more complex than he has indicated.

The cliffs on the Waiareka River call for little special detailed mention. They are mostly formed of the "barren breccia," and exhibit a great deal of irregularity in stratification, perhaps due to current bedding. In one place a few fossils were found, but they were too weathered for identification. The "mineral breccia" contains all the minerals found in the first exposure, and biotite in addition. The breccia is slightly less coarse than at the other exposure, the largest fragments being 75 mm. in

* Trans. N.Z. Inst., 1886, pp. 415–30.

diameter. Garnet, both in combination with other minerals and free, is more abundant here than elsewhere.

The exposure two miles north of Kakanui showed a limestone resting on the "mineral breccia." The limestone in its upper layers has the characters of the ordinary Ototara stone, but the lowest few feet are more fossiliferous and resemble the Kakanui quarry limestone. This goes to prove that the Kakanui limestone is, as Mr. McKay remarks (*loc. cit.*), a local development of the lower layers of the Ototara stone. The fossils found here were: *Flabellum*, sp.; *Isis dactyla; Graphularia*, sp.; *Terebratella gualteri; Liothyrina*, n. sp.; *Rhynconella squamosa; Pecten hutchinsoni;* and *Cidaris* spines.

The sequence on the river-bank on the South Head is important as showing that a limestone underlies the volcanic rocks, the limestone forming wherever the sea-bottom was not subjected to a shower of cinder from the neighbouring volcanoes. The basement limestone is similar in microscopic structure (sections) to the others in the locality. It contained a few fossils, those collected being *Liothyrina*, n. sp.; *Pecten*, sp.; and *Lamna*, sp.

The overlying marl has few fossils. It would probably be a very suitable material for cement-making when mixed with some pure "white" limestone, but its small thickness and the overlying gravels would prevent it from proving a cheap material to work.

The "mineral breccia" in this exposure is much finer in grain than in the others. It contained most of the minerals found on the opposite side of the river, and black mica in addition. The overlying limestone is rich in fossils; the following were obtained: *Liothyrina*, n. sp.; *Terebratella gualteri, Terebratella aldingi, Magellania lenticularis, Rhynconella squamosa, Pecten hochstetteri, Pecten yahlensis, Pecten hutchinsoni, Dentalium mantelli*, and numerous *Cidaris* spines.

The isolated exposure of limestone at the mouth of the river appears to be flat. It may lie on top of the "mineral breccia" exposed a little further east. If, however, it should be the same as that just mentioned, some displacement of the strata must be assumed.

The development of the "mineral breccia" at the South Head is somewhat like that on the North Head, but the outcrop lines cannot be traced on the beach, because of its steeper and more shingly nature. The inclusions are largest about the middle point of the cliffs. The dimensions obtained were: Hornblende, average, 12 mm.; black augite, 70 mm. by 25 mm., 60 mm. by 75 mm. by 35 mm.; feldspar, 40 mm. by 25 mm.; biotite, 40 mm. by 40 mm. by 12 mm.; holocrystalline inclusions, 150 mm. by 100 mm., 125 mm. by 100 mm., 175 mm. by 200 mm., 25 mm. by 40 mm. A basalt block 5 ft. by 4 ft. by 1 ft. contained—Hornblende, 75 mm. by 50 mm.; black augite, 50 mm. by 40 mm.; biotite, 25 mm. by 12 mm.; green augite, 6 mm.; holocrystalline inclusions. This large block of basalt suggests proximity to the crater. It is possible that the sudden changes of dip may be due to the opposite directions of dip inside and outside of the crater.

One point regarding the origin of the inclination of the rocks might perhaps be discussed here. Captain Hutton in the paper referred to* states his conclusion that the Ototara limestone is the remains of several old coral reefs built up round small volcanic islands near the coast, and that it retains its original plane of deposition. This explanation seems to be pretty well borne out by the observations on the locality, but the syncline of the "mineral breccia" shown in the section of the North Head requires a hypothesis of folding.

The fossils obtained in the layers of the breccia to the south were as follows: *Nothothyris suessi* and *Waldheimia lenticularis*. The overlying limestone was rather glauconitic below, but passed into a hard coral reef above. The surface is easily denuded of the overlying greensand, and much eroded. It was formed chiefly of corals, especially *Flabellum circulare* and *Isis dactyla*, and *Lamna*, sp. The overlying greensand is very fossiliferous, and contains *Isis dactyla; Isis*, n. sp.; *Magellania sinuata; Terebratella*, n. sp.; and *Fusus*, sp. (casts).

There was no contact here with the blue clay seen further south. Captain Hutton (*loc. cit.*) says, "The unconformity between it and the underlying limestone is plainly to be seen in the coast section, not only in the difference of dip, but also in the denuded surface of the limestone (Section iv)." This appears inconclusive, for the denuded surface of the limestone is due to recent removal of the greensand and subsequent weathering. The difference of dip is more conclusive, but, compared with the general run of dips in the locality, is not very surprising. Still, there is a probability of unconformity from the fact that no contact is seen, and from the general flat nature of the blue clay. The fossils obtained in it were *Flabellum circulare, Dentalium mantelli, Turritella rosea, Scalaria rotunda, Solonella australis*, and *Cucullæa*, sp. A whale was also found. Of these *T. rosea* and *S. funiculata* are not recorded elsewhere from the Oamaru system, and go to prove that the beds belong to the Pareora and not to the Oamaru system.

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* Trans. N.Z. Inst., 1886, p. 421.

Remarks on Stratigraphy.

From the above description, the matrix of the Kakanui "gem gravels" is seen to be a submarine volcanic breccia occurring on or near the sea-coast at the mouth of the Kakanui River. It is covered in all exposures by a limestone having the same nature and bearing the same fossils as the Ototara limestone, so that its stratigraphical position is in the Oamaru system. From the nature of the fossils in the breccia, and the occurrence of glauconite in and above the limestone, the formation of the breccia must have taken place at a considerable depth below sea-level. Should this breccia prove to be a matrix for gems, there would be three or four exposures where it might be quarried, and a surface-area of some acres. As there must have been one or more craters from which the breccia was erupted, there must be pipes running down to a considerable depth, and most likely containing larger fragments of mineral and less calcite. These could be worked by mining, although the permeable nature of the breccia might allow of a large influx of water. Should gems occur, they would probably be of a sufficient size in these pipes to repay working.

Identifications of the Minerals and Rocks contained in the Breccia.

Complete and detailed descriptions of these minerals will be of considerable petrological interest, but are withheld till further work has been done. It will be sufficient here to state that, after a considerable amount of chemical and microscopic examination, the following were identified :—

Black augite Hornblende Feldspar, near oligoclase	in large fragments.
Garnet Diopside Diallage Biotite Olivine Smaragdite	in smaller fragments.

Basalts.

Sandstone, limestone, greywacke.

Quartz, mica-schist, granulite, and garnet gneiss.

Various basic plutonic rocks, which may be grouped in two classes—(1) lherzolites, eulysites, and wehrlite (containing fine spinels) ; (2) garnetiferous peridotites.

The basalt contains inclusions of almost all the other rocks and minerals found in the breccia.

There is no trace of any gem of value in either the "gem sands" or the breccia, although the garnets and green augites would make pretty stones when cut. There are many points of geological interest, however, about the breccia which make a more complete examination of interest. In the first place, the presence of granulite and gneiss point to the existence, at no great depth, of such rocks as form the Wanaka formation, of the west coast of Otago.

The fact that so many of the minerals have a rounded form and high polish wants explanation.

The similarity, both in occurrence and composition, of the holocrystalline rocks to those of Kimberley at once raises the interesting question, Is it probable that diamonds will be found at Kakanui? This similarity is probably the reason that Professor Ulrich considered there was great probability that gems would be found at Kakanui. It will be of interest to discuss this similarity. Both occurrences are volcanic breccias; both are calcareous, the Kimberley breccias being now only seen in pipes or the necks of old craters, the Kakanui being well stratified and originally submarine; there must, however, be necks, and probably one occurs on the South Head. Both consist mostly of ultra-basic minerals and rocks. At Kimberley no volcanic rock is present, at any rate in a recognisable state; at Kakanui there is a limburgite or feldspar-free basalt, whose explosion may be assumed to have caused the eruption.

The amount of alteration that the Kimberley breccia has undergone has almost disguised its original character, and it is sometimes taken as a rock species. It has been shown by Bonney, however, that this alteration has had nothing to do with the formation of diamonds. Both breccias contain rounded rock-fragments.

The following isolated minerals are recorded from Kimberley: Enstatite,*† topaz,* chrome-diopside,* diallage,* iron-pyrites,* ilmenite,*† olivine,† smaragdite,† chrome-diopside ("omphacite" of some authors),† a brown mica,† garnet (mostly pyrope, but more than one variety observed),† magnetite,† chromite.†

The following rock-fragments are recorded: Garnet-green pyroxene (omphacite) rock = eclogite,* bright-green pyroxene, zoisite purple-garnet rock,* pyrope-chrome diopside (olivine) rock = eclogite,† garnet-diopside-mica-enstatite rock = enstatite eclogite,† garnet-bastite rock,† olivine-bastite rock = saxonite,† garnet-enstatite-chrome-diopside-olivine rock = granatiferous

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* Bonney, "Geological Magazine," 1891, pp. 413, 414.

† *Ibid.*, 1899, p. 309.

lherzolite,* olivine-bastite-green-augite-pyrope rock = enstatite eulysite,* pegmatitic hornblende gabbro.

The Kakanui breccia, then, contains six rock-forming minerals also found at Kimberley—viz., olivine, diopside, diallage, garnet (two varieties), smaragdite, and spinel (*cf.* chromite). Both contain lherzolites and eulysites, and each contains two granatiferous peridotites—viz., eulysite and eclogite at Kimberley, and eulysite and garnet-pyroxene as Kakanui.

The diamond at Kimberley is found included in the eclogite and in the pyrope. Dr. Bonney considers the garnet very important: "As the ordinary varieties of the latter mineral [garnet] seem to be produced at a high temperature, the association [of diamond with it] may be significant."

The origin of the diamond at Kimberley has been traced to a pyrope in an eclogite. The diamond is included in the pyrope as well-formed crystals. Its ultimate origin is obscure, as the parent rock has so high a percentage of oxygen that, according to Dr. Bonney, it is difficult to understand how so small an amount of carbon escaped oxidation. It seems as if the diamond formed in some more basic magma, and had been either taken up by the eclogite magma, or the magma containing it had mixed with one or more acid to form the eclogite magma. In any case, under the present amount of knowledge, the presence of diamond in an eclogite cannot be taken as a sign that diamond occurs only in eclogite, or that all similar eclogites contain diamonds. Many eclogites occur elsewhere without diamonds.

Under these circumstances, to establish a resemblance between the breccias at Kakanui and at Kimberley will give a possibility that diamonds occur at the former place, but not a very high degree of probability. The presence of two distinct garnetiferous peridotites in the former and of several in the latter creates a great similarity, and shows a similarity of conditions—magmas with little alkalis and crystallizing at a high temperature. Such a similarity is of sufficient interest to justify a thorough examination of the New Zealand locality, both from a theoretical and practical point of view.

The occurrences resemble one another also in that both are volcanic breccias. This can only bear on the subject in that, as diamonds would only be likely to occur in ultra-basic rocks, and as such rocks generally occur at a great depth in the crust, there would be greater probability of their occurrence in a rock formed from deep-seated eruptions than in any other way.

In regard to the other point of similarity, the occurrence in both breccias of rounded fragments, Dr. Bonney has proved to

* Bonney, "Geological Magazine," 1900, pp. 476–79.

his own satisfaction that the rounded form is due to the inclusion of waterworn fragments from deep-seated conglomerates. In the present case there is no evidence to show that such has happened. The rounding and polishing is so fine that it can only have been caused by friction, and the only suggestion that has occurred to me is that which Dr. Bonney rejects in the Kimberley case—viz., that the fragments have been rolled up and down in the crater. This point, however, has no bearing on the probability of the occurrence of diamonds.

In conclusion, from the similarity of the Kakanui breccia to that of Kimberley, it would excite no surprise if they were discovered, but it could hardly be predicted that diamonds occur at Kakanui.

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Art. LIV.—*Two New Ferns.*

By H. C. Field.

[*Read before the Wellington Philosophical Society, 5th April,* 1905.]

In December, 1903, one of my sons, who had been visiting Auckland, brought me some plants of ferns which are either wanting or extremely rare in this part of the colony, and I potted them at once. Among them was one which appeared strange to me, and which my son said he had found in some scrub near Takapuna Lake. It was a male plant with only barren fronds about 2 in. long, and which looked like those of young *Lomaria filiformis*, but seemed too thick and harsh to be so. It was also a tufted plant, having a crown of about a dozen fronds, without any sign of the creeping roots which are characteristic of *L. filiformis.* The plant grew well, but it was not till near the end of the following year that it began to produce fertile fronds, which were rose-coloured when young. This is so common with *Lomaria lanceolata*, particularly when growing on limestone soil, that I thought the plant might be a peculiar northern form of that fern. As the new fronds developed I saw that the plant was a *Doodia*, though different from either *D. media* or *D. caudata*, both of which I have had growing for many years. It has more of the peculiar tailed pinnæ of *D. caudata*, and differs from *D. media* in many respects. I have had plants of *D. media*, not only from the neighbourhood of Wanganui, but from Wellington, Nelson, and Auckland, and they were precisely similar in every case. There were never more than three or at most four fronds on a crown, and these were lanceolate. In fact, I never could see any difference between *D. media* and the Australian *D. aspera*, except that the former was a much larger plant, and had rather fewer fronds. The new Auckland plant has no less than twenty-one fronds, and these, instead of being lanceolate, have their pinnæ of nearly equal length throughout, and these shorten and taper rapidly towards the apex of the frond. The pinnæ are also far shorter and more obtusely pointed than those of *D. media.* Thus, though approximating to the latter, the fern is of a far more handsome and compact habit—so much so that I think it worthy of being separately classed, and would suggest *Doodia aucklandica* as a fit name for it.

In July, 1903, I received a parcel of ferns from Waikanae. They had been taken up with lumps of earth in which they grew, but as they had been several days out of the ground, and reached me late in the day, I potted them without much examination. There were several plants of *Botrychium ternatum*, variety *cicutarium*, and what appeared to be a cluster of *Botrychia* growing close together. The plant grew well, but I paid no particular attention to it till I put it in as one of a collection of ferns exhibited at our spring horticultural show on the 30th November. During the show the Rev. Z. Spencer, who has collected ferns for very many years, and has the best collection of pressed specimens of any one in Wanganui, remarked that I seemed to have wrongly labelled the plant, and that it seemed to him to be a *Pteris*, though one which he did not know. This caused me to observe the plant more carefully, and I found that he was right. The plant is clearly a *Pteris*, but differs materially from either of those yet classified as belonging to the colony. It approximates to *P. tremula*, but has important differences. *P. tremula* has not more than six or eight fronds forming the crown, and these have very long stalks, are broadly triangular or rhomboidal in form, and are of a light-yellowish-green colour. The new plant has now twenty-one fronds in its crown, and these are so narrowly rhomboidal as to appear almost lanceolate, while the stalks are quite short. The colour is a dark almost olive green, and the strong aromatic scent which belongs to *P. tremula*, and which is so powerful as to be actually unpleasant in hot weather, is entirely wanting. Again, the ultimate divisions of *P. tremula* grow touching each other, are $\frac{1}{2}$ in. or more long by about $\frac{1}{10}$ in. wide at the bases, which are completely sessile, and from which the divisions taper gradually to sharp points, the fructification extending along the whole length of both sides. In the new plant these ultimate divisions are much further apart, and so narrowly sessile as to be almost stalked. Above this apparent stalk they widen suddenly for $\frac{1}{4}$ in. or more, and then become ovate or very bluntly pointed. In many instances they are cut into shallow lobes, and in such cases the fructification is confined to the outer portion of the lobes. But perhaps the greatest distinction is in the habit of the plant's growth. *P. tremula* has an erect habit, the crown gradually rising till in old plants it becomes a caudex 1 ft. or more in height. The new plant, on the other hand, spreads horizontally by the production of lateral fronds, so that even now it is rapidly filling a pot 5 in. in diameter. Altogether, though approximating, as I have said, to *P. tremula*, it is very different in appearance, and far more compact and handsome than that fern; and I think the differences are such as to make it worthy of being separately classed. The late Mr. Travers had a house at Paraparaumu, and I thought this fern might have grown from spores of some kind which he had in cultivation; but I cannot learn that he had such a plant, and there is none mentioned in the "Synopsis Filicum" which seems to agree with it. I think, therefore, that it may be provisionally named *Pteris novæ-zelandiæ*. It may be observed that in both the above cases the plants approximate to some already classified, but that they are such an improvement on those others, particularly in their habit of growth, as to seem to deserve separate classification. Though there is great variation in some of our New Zealand ferns, yet in every case the changes seem to have been evolved gradually, as there are connecting-links between the different forms which are difficult to assign to either. In both the cases, however, which I have mentioned the change is more than that of mere form — it is of habit of growth; and, if a change, has apparently been evolved suddenly. The *Doodia*, for instance, is so totally different from the ordinary *D. media*, even as found at Auckland, that no one only partially acquainted with our New Zealand ferns would for an instant regard the two as merely different forms of the same plant.

I observe that in a paper published in the last volume of Transactions Mr. A. Hamilton quotes a remark which I made in 1882 as to the apparent paucity of cresting in our New Zealand ferns, a view in which the late Professor Kirk and Mr. H. F. Logan concurred with me. Since that date I have met with sundry examples of crested ferns, and have at present such forms of *Adiantum formosum*, *Hypolepis distans*, and *Pteris tremula*. In my book on our ferns a very remarkable dwarf form of *Polypodium pennigerum*, which was a mere mass of cresting, is figured on pl. xxv. It seems to me that cresting arises from plants growing under some particularly favourable conditions, as in several cases my plants have become so under cultivation. I notice that when a plant thus breaks away from the normal type, seedlings from it are apt to exhibit the peculiarity in even an exaggerated form, and I think that the great variety of appearance in the English ferns has arisen from persons having taken up and cultivated plants which presented any peculiarity. Before I became blind I had more than twenty quite distinct forms of the English lady fern, and about fifteen of the male fern, as well as hart's-tongue fern, which was a mere mass of cresting. Even now I have a form of lady fern in which the pinnæ are depauperated into mere semicircular projections from the midrib, and then have a heavy tassel of cresting at the end of the latter. Anything more different from the ordinary type of the lady fern it would be hardly possible to conceive. Mr. Hamilton's peculiar examples seem to have been mostly of one kind of fern, *Lomaria fluviatilis*, and to have been found in one specially favourable locality—which agrees with what I have above stated as to these peculiarities being worked under particular conditions. I was very glad to see that he was drawing attention to these variations, as they are very interesting to lovers of our ferns, and should be reported when observed. I think it is a great pity that more people do not cultivate our ferns, as many of the rarer and more delicate ones bid fair to become extinct as the country is cleared and brought under cultivation. It is very interesting to grow ferns from the spores, and it seems to me that this will be the only means of preserving some kinds.

Art. LV.—*Notes upon a Find of Kauri-gum in Rangitikei, Wellington Province.*

By S. A. R. Mair.

[*Read before the Auckland Institute, 9th October,* 1905.]

Some five-and-twenty years ago a broad expanse of dense bush separated the lower Rangitikei from the extensive plains of Murimotu, or Inland Patea, lying to the south of Ruapehu. Right from the Whanganui River to the Ruahine Ranges did this forest extend, and, except for occasional canoe services down the Rangitikei River, it completely barred all communication with the ports of Cook Strait. Many acres of the plains had even then long been used for grazing sheep, brought in overland from either Hawke's Bay or Taupo, by which routes wool, &c., had to be packed out. This led to an agitation to open communication through to Rangitikei, as the Maoris were supposed to have previously had a track through the intervening thirty or forty miles of bush. With this object the Government and Rangitikei County offered a reward of £250 for the best line of road, and by this means the bush was thoroughly explored by Natives and pioneer settlers, with the result that a track was opened through about midway between Turakina and Rangitikei Rivers. This line, known as Murimotu Road and Murray's Track, was only one of several routes offered for the reward, and evidently, by being adopted, was considered to be most serviceable. Leaving the lower Rangitikei it followed up the Pourewa, a large feeder of the Rangitikei River, and, climbing out of its source over the Te Kumu Ridge, about 2,500 ft. high, it rapidly descended a sharp ridge into the Mangaone Stream, a feeder of the Mangapapa, which in turn flows into the Turakina. Rising out of the Mangaone up and over a western ridge off the high Matawa Range, the track traversed some miles of gorgy and hillocky country, emerging into the Patekete clearing, and then into the valley of the Hautapu, up which it wound to Ngaurukehu and Turangarere, where the Ruanui, Taupo, and Moawhango–Napier Roads were intercepted.

Whether the explorers of Murray's Track had known of the previous existence of any ancient Maori track between the Rangitikei and Patea I am not aware, but have since been informed by Major Mair that such a track did exist, and was used from the very earliest times by the interior Maoris visiting those on the south-west coast. From Major Mair's testimony I find this track from Turangarere to the Mangaone was almost identical with Murray's Track. From there it rose the spur to Te Kumu Ridge and there divided, the western branch heading the source of the Pourewa on the northern side, and, after passing around Tauporae, followed a spur down to the Turakina River, just below where it is joined by the Mangapapa. About here are to be seen many remains of old cultivations and fortifications, possibly being a place of retreat, as it is at the head of the portion of river navigable for canoes, and some forty or fifty miles from the coast. The eastern branch skirted the source of Pourewa, falling into the valley of the Makohine, another tributary of the Rangitikei, and again ascending the Whakawae Ridge and descending to the Otara kainga, near where Ohingaiti now stands. From there to the coast communication would be easy either by canoe or down the valley of the Rangitikei.

The subject of these notes, a large piece of kauri-gum, was discovered by some bushfellers lying on a leading ridge parallel to the one which Murray's Track follows, immediately to the south and about 30 chains from the Mangaone Stream. One of the bushmen, in preparing to boil the "billy," observed what he expected was a round stone, and, as such is a curiosity in this country entirely devoid of gravels, he inquisitively struck it with the back of his axe, to find it splintered into fragments of gum. Finding it would burn he utilised the most of it to boil his precious "billy," but luckily he retained a few pieces, and I afterwards obtained a few ounces from him. From his description the lump would be several pounds in weight, and was completely moss-covered, and lying half buried in the mould near the crown of a sharp ridge, in dense bush; and there were absolutely no indications of any track of any kind, the undergrowth being, if anything, denser than usual. There would be no old Native clearings within ten or twelve miles of the spot as the crow flies. As will be observed by the sample forwarded with this, the gum is a hard, brittle, semitransparent gum, to all appearance just as if taken out of the ground.

Upon ascertaining that the find was really kauri-gum, a mild sensation was caused among the immediate settlers, who were then led to believe their lands had once been clad with kauri, and would in future be rushed by diggers anxious to search for the buried wealth. Howevei, possible such a thing may be, but it is most improbable.

Geologically the country throughout this part consists of the lower and middle beds of Tertiary clays, commonly known as "papa," and covered with a comparatively thin coating of clay mould. The existing forest consists of totara, rimu, kahikatea, matai, tawa, titoki, kowhai, &c.

The presence of this kauri-gum in such a locality, together with the traditional record of an ancient track by the Maori, may be taken as conclusive evidence as to the actual existence of such, and also go to show that kauri-gum was put to some use by the ancient Maori, or a lump of several pounds would not have been carried upon a long and presumably fighting trip from the far north.

It may not be generally known that the kauri will flourish in the extremes of weather in this part of the Island. In my garden at Hunterville I have a fine tree, about four years old, which makes a growth of 9 in. each year. It was obtained from a Wellington nurseryman, and has several times been transplanted, and, in its present situation at 900 ft. above sea-level, has experienced several severe snow-falls lasting days at a time. It is now about 4½ ft. high.

Appendix by Captain Mair.

Traversing the large tract of forest which lies between the open country about Rangitikei and the Murimotu Plains were two well-known ancient war-trails, which were much used in the sanguinary wars that occurred during the early part of last century. One of the aforesaid war-paths came from Hawke's Bay and Taupo, joining at Pungataua, thence crossing the cañon of the Moawhango by a narrow plank (settlers still use a log on same site) it followed along the Whakauae Range out to a clearing called Otara on bank of Rangitikei, thence to Pourewa, and on to Marton. The other track branched off from the former at Turangarere towards the west, thence down the valley of the Pourewa to Marton. It was by these two war-trails that the three *hekes* or migrations composed of the Ngatiraukawa under Te Whatanui, Te Heuheu, and other great chiefs, came to assist their kinsman Te Rauparaha in holding Kapiti as against the populous but less warlike southern tribes. Armed bands were, in fact, constantly passing over this country, and the large lump of kauri-gum recently found in this district had evidently been brought from the Thames, Lower Waikato, or Raglan district by one of these very numerous war-parties.

The old-time Maori carried kauri-gum for several reasons: first, for burning under sheets of green bark to procure lamp-black (kauri), from which the tattooing pigment was made; secondly, for use as torches; and, thirdly, for chewing. To prepare the latter the old gum was kept in boiling water till quite plastic, then juice procured from the milk of the *puwha* (thistle) was mixed with it to make it soft and elastic for masticating.

Art. LVI.—*Brief Notes on the Theory of New Zealand Earthquakes.*

By G. Hogben, M.A.

[*Read before the Wellington Philosophical Society, 4th October,* 1905.]

Plates LIII and LIV.

From time to time papers have appeared in the Transactions of the New Zealand Institute and of the Australasian Association for the Advancement of Science dealing with individual earthquakes. Captain Hutton's monograph on the Amuri earthquake of the 1st September, 1888, marked a new epoch in seismological science in New Zealand, as it treated the facts of that disturbance in accordance with the ideas of modern seismology. I have published during the last sixteen or seventeen years several other papers in which I have endeavoured to follow the same general lines in regard to all the important shocks that have occurred. Although, perhaps, we cannot yet with any certainty elaborate a complete theory of the earth-movements in the New Zealand region, nevertheless it appears to me that the time has arrived when we may attempt to co-ordinate the facts in our possession by some general explanation of them so far as the earthquakes enable us to do so.

The most accurate observations made in the colony have been those afforded by the two Milne horizontal pendulums installed at Christchurch and Wellington respectively. Some of the inferences to be obtained from their records, or seismograms, may be most readily understood by means of a few general remarks; as illustrations I take the copies of four seismograms on the New Zealand instruments (Plate LIII, figs. 1–4).

Fig. 1 on Plate LIII is a copy of the Christchurch record of the great Guatemala earthquake of the 19th April, 1902. The time is Greenwich mean civil time.

Fig. 2 shows a severe earthquake, on the 20th November, 1902, from an origin probably near 21° S. lat., 172° W. long.—that is, north-east of Tonga (Wellington record, G.M.C.T.).

Fig. 3 is the Wellington record of the earthquake at Cheviot, New Zealand, on the 16th November, 1901, beginning at 7.47 a.m., New Zealand mean time.

Fig. 4 is a copy of the seismogram taken at Wellington of the East Coast earthquake of the 9th August, 1904 (G.M.C.T.).

The small letters *a*, *b*–*h*, above fig. 1 mark the beginning of the eight phases into which Professor Omori divides the waves. The most important of these are: *a*, the beginning of the preliminary tremors; *e*, the chief of the large waves; *h*, the last marked phase of the series. The position of the corresponding waves on fig. 2 is marked by the letters *a*, *e*, *h*. In figs. 3 and 4 the downstroke on the margin shows the beginning of the preliminary tremors (*a*); the black line right across the seismogram gives the position of *c*, *d*, and *e*; the last phase (*h*) is shown in fig. 3 by another downstroke, but cannot be distinguished in fig. 4.*

As I have stated in a former paper, the times of arrival of these waves (*a*) at the various seismological stations of the world appear to show that they travel round the earth, and not through its central portion—that is, along arcs parallel to the surface, and not along chords. That is certainly true of the other waves (*b*–*h*).

The following table shows the transit-velocities of the chief waves of the four earthquakes just referred to, in kilometers per second:—

Earthquake.		*a* Waves.	*e* Waves.	*h* Waves.
Guatemala	..	15·6	3·2	2·1
Tonga	..	13·0	3·3	2·2
Cheviot	..	12·4	3·5	2·3
East Coast	..	12·5	3·5	2·3

The high transit-speed of the *a* waves or preliminary tremors can be accounted for only on the assumptions—(1) that the vibrations originated in rocks under a maximum strain (it will be remarked that the speed is greatest for the earthquake of greatest intensity); (2) that their path through the earth's crust was the path of maximum velocity, and therefore through the rocks of highest rigidity and elasticity.

The velocities of the *e* waves and *h* waves for various large earthquakes seem to vary very little, the average being 3·3 and 2·2 kilometers per second respectively. Now, from theory based upon the experimental determinations of the rigidity, elasticity, and density of various rocks, the speed of large normal or longitudinal vibrations through such rocks as hard granite is estimated to be between 3·1 km. and 3·95 km. per second, and the speed of transverse waves two-thirds of that of normal waves proceeding from the same origin at the same time and along the same path.

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* The fact that the interval between the arrival of the preliminary tremors and of the normal waves is very small when the origin is near, and increases with the distance from the origin, is explained on the assumption that they start at or about the same time from the origin, and gradually become separated owing to the d fference in their transit-speeds.

It is therefore highly probable that *e* and *h* on the seismograms (of which those given are fair specimens) represent the chief normal and transverse waves, due respectively to elasticity of volume and to elasticity of form. Now, if the rocks were subjected to great pressure, as must be the case at a few miles below the surface, the strain would be at a maximum just before yielding, and the consequent vibrations (*a*) would be small and rapid ; as the rocks yielded to the strain and were compressed, larger and slower vibrations (*e*) would be produced ; distortion of the rocks would also generally take place, giving rise to transverse waves (*h*). The conditions would be satisfied if, under unequal vertical or lateral pressures in two adjoining portions of the earth's crust, there occurred bending or folding of the strata, accompanied or followed by fracture of the rocks such as give rise to faults ; there would be earthquakes, in fact, whenever any sudden adjustment took place, whether such adjustment were rapid tilting, the formation of a fracture, the rapid sliding of one rock-face over another, or simply the crushing of rocks under great increase of pressure, or, what is most probable, several of these causes operating together.

Have we any evidence that these conditions have been satisfied in the case of New Zealand earthquakes ? The great earthquake of 1855 affords evidence that they have been satisfied in at least one instance. The origin—that is, the moving portion of the earth's crust—was at least as large as is indicated by the oval drawn on the map (Plate LIV). The evidence is very clear that on the north-eastern side of this area the elevation was greatest ; that it diminished towards the middle ; that there was neither elevation nor depression in Porirua Harbour ; and that on the south-west side of the focal area there was a depression of at least 5 ft. This tilt, or folding, as we may fairly call it, was also accompanied by fracture of the rocks, showing itself by surface rifts that ran for many miles north-east and south-west.

Again, reference to the map will show that the line joining Wellington and the epifocal area of the Cheviot earthquake of November, 1901, is nearly parallel to the general axis of New Zealand ; a great rift (called by Mr. A. McKay, Government Geologist, "the Clarence fault") runs nearly in the same direction, and it is quite probable that it indicates the existence of a deep fault. The significance of this will be seen if we turn to the Wellington seismogram of the Cheviot earthquake (fig. 3) ; it will be observed that the mean position of the central or zero line after the shock is nearer the lower edge of the paper—that is, nearer the west—than it was before the shock : this shows that the surface of the earth on which the column rests was tilted through an angle of about 1·3 seconds towards the west or north-west.* This tilting took place suddenly; but it is interesting to note that for some months before the earthquake a gradual lowering of the level on the west side had been taking place, and that a similar gradual movement has been going on up to the present time (September, 1905). The 1901 earthquake therefore gives us an example of tilting, or folding, in which the original fracture of the rocks did not apparently extend to the surface.

It is well known that strata originally more or less horizontal have been folded by forces acting on the earth's crust, the folds often appearing at the surface so as to form wrinkles or mountain ranges and valleys. Several possible causes of this folding may be assigned. Two of the most important are—(1) the gradual cooling of the earth; (2) the loading of the ocean-bed through denudation of the land-surface.

(1.) As to the cooling of the earth: The temperature of the rocks near the surface, being the temperature of space modified by the heat from the sun's rays, is practically constant; so that those rocks will not contract. All other layers of the crust will cool and contract at rates varying with the depth. The volume of the layers in which cooling is greatest will, after contraction, be too small to fill the space into which the layers fall, and they will therefore be pressed out by the weight of the rocks above them. But the upper strata, which cool less quickly, will be too large to fill the space into which they fall, and their surface will accordingly be crumpled. The effect will be to produce a series of elevations and troughs (anticlinal and synclinal folds). The folding or crumpling is determined partly by previously existing lines of weakness, partly by inequality of vertical pressures due to differences of texture and density in the upper layers. Unequal *vertical* pressures on adjoining portions of the earth's crust will cause unequal *lateral* pressures, and a tendency for the rocks to "creep" or move horizontally in order to repack themselves in a more stable condition. This lateral thrust, again, may produce fractures, reversed faults, and elevation of those strata which are less dense or subject to a smaller vertical pressure. Obviously, earthquakes will occur whenever any of these movements are sudden in character.

(2.) "Loading": Another cause of folding is the transference of material from the land-surface to the bottom of the sea by the agency of rivers: the pressure on the strata underlying the land will be thereby relieved, and the pressure on the floor of the ocean will be increased. There will thus be a

* In the 1855 earthquake the angle of tilt could not have been less than 4 seconds, and may have been as much as 10 seconds.

folding of the strata near the junction of the land-surface and the ocean-bed, which may continue until fracture takes place, the strata on the land side moving up, and those on the ocean side moving down. The displacement of the strata will form a normal fault. After the fracture the two faces of the strata will continue to slip and to slide one over the other so as to increase the amount of displacement. The slipping may go on very gradually, but from time to time sudden slips will probably occur, and these will produce earthquakes. All the recent earthquakes in New Zealand have been followed by other shocks, showing that the slipping of the rocks has continued for some time after the principal shock. Again, as in the case of folding due to cooling, the differences of vertical pressure will induce lateral thrusts, tending to cause "reversed faults"; but in this case the tendency will be most marked at a considerable depth below the surface, where the pressures are greatest. Subsequent action may raise the deeper rocks, and reveal faulting that has occurred ages ago.

The facts in regard to the folding of the crust are not, of course, so simple as they have been stated here; but, generally speaking, all the movements resulting from unequal vertical and lateral pressures between the rocks may be summed up in the term "repacking."

The evidence already given is perhaps not sufficient to establish completely the theory that earthquakes generally are connected with fault-movements and similar processes of repacking of the strata, but it makes that theory highly probable. It must be remembered that the value of such evidence necessarily depends upon its cumulative weight, and it would be too tedious to give a large mass of evidence of this kind here. Moreover, our knowledge of the position of the geological faults in New Zealand is too limited as yet to prove the theory from New Zealand examples. Dr. Charles Davison, an able British seismologist, has shown in a very careful series of investigations the connection between many British and European earthquakes and known lines of fault.

A study of the map of the seismic origins in the New Zealand region (Plate LIV) will strengthen the evidence already given in favour of the theory. Before considering these, it may be as well to name the nearest known origin outside the New Zealand region.

On the 27th January, 1892, an earthquake of the intensity VII–VIII (Rossi-Forel scale)—probably X near the origin—was felt over almost the whole of Tasmania, in Victoria as far west as Melbourne, and in the south-east part of New South Wales, *but not in New Zealand*. The epicentrum was about 353 miles east of Launceston; it lies on the western slope of the Thompson Basin, the great trough in the Tasman Sea. The same region contains the origins of at least three well-marked Tasmanian earthquakes—namely, those of 13th July and 19th September, 1884, and 13th May, 1885.

From April, 1883, to December, 1886, 2,540 shocks were recorded by Captain Shortt, R.N., of Hobart, and his assistants, nearly all being very slight. Probably the earthquakes just named above were due to the principal movements, and the numerous smaller after-shocks or tremors indicated the slight adjustments of the Tasmanian land-mass. We have yet to discover what connection, if any, there is between these and other movements in or near Australia and Oceania, and those of New Zealand. Most of the evidence available seems to point to the hypothesis of a general elevation of the floor of the Western Pacific; but the evidence so far is very meagre and disconnected.

In the case of the New Zealand earthquakes, on the other hand, I think that a careful study of the map and of the facts mentioned in the text will immediately suggest the theory that our earthquakes are incidents in the history of folding and similar movements that have been going on for ages, the axes of the folds being parallel to the general axis of the country.

The *origins* of the New Zealand seismic region will be seen to arrange themselves in groups as follows:—

Group I.—Earthquakes felt most strongly on south-east coast of North Island; epicentra form a strip 180 miles from the coast, parallel to the axis of New Zealand, and to axis of folding of older Cainozoic rocks in Hawke's Bay. Chief shocks: 17th August, 1868; 7th March, 1890; 23rd and 29th July, 1904; 9th August, 1904 (intensity IX on R.-F. scale); 8th September, 1904; prob, 23rd February, 1863 (IX, R.-F.); &c.

According to Captain F. W. Hutton, F.R.S., the geological evidence shows that New Zealand rose considerably in the older Pliocene period, and was then probably joined to the Chatham Islands. At a later period subsidence occurred, followed again by elevation in the Pleistocene period, with oscillations of level since. The seismic origins of this group are at the foot of a sloping submarine plateau, about two hundred miles wide (marked B on the map), which culminates to the east-south-east in the Chatham Islands. This elevation is separated from the New Zealand coast by a trough from 1,000 to 2,000 fathoms in depth, which is widest and deepest at A A—that is, between these origins and the mainland.

Group II.—(*a*.) South-east of Otago Peninsula. Shocks: 20th November, 1872, &c.

(*b*.) A strip south-east of Oamaru. Shocks: February, 1876; April, 1876; &c.

(*c.*) Many short and jerky, but generally harmless, quakes felt in Christchurch, Banks Peninsula, and mid Canterbury. Chief shocks: 31st August, 1870; 27th December, 1888 (VII, R.-F.); &c. Focus of 1888 shock, sixteen miles long, from west-south-west to east-north-east, twenty-four to twenty-five miles below surface, being deepest ascertained origin in New Zealand region.

These origins form a line parallel to the general axis of the land. It is quite possible that the loading of the sea-floor by the detritus brought down by the rivers of Canterbury is a contributing cause of the earthquakes of this group.

Group III.—Wellington earthquakes of January, 1855, and Cheviot earthquakes of November, 1901.

Remark has already been made as to a possible relation between these origins. The great earthquakes of October, 1848, probably came from the same region as those of January, 1855. The chief shocks of both series did extensive damage to property, and caused the formation of large rifts in the earth's surface; they are the only seismic disturbances since the settlement of the colony that can be assigned to degree X on the Rossi-Forel scale.

Group IV.—(*a.*) Region about twenty-five to thirty miles in length, and, say, ten miles or less in width, running nearly north-north-east from middle of Lake Sumner, about twenty miles below the surface, whence proceed most of the severer shocks felt from Christchurch to the Amuri, and a large number of minor shocks. Chief earthquakes: 1st February, 1868; 27th August to 1st September, 1871; 14th September and 21st October, 1878; 11th April, 1884; 5th December, 1881 (VIII, R.-F.), when Christchurch Cathedral spire was slightly injured; 1st September, 1888 (IX, R.-F.), when upper part of same spire fell, and still more severe damage was done in the Amuri district.

(*b.*) A small, shallow origin not more than five to ten miles below the surface, a few miles south of Nelson. Earthquake: 12th February, 1893 (VIII to IX, R.-F.); chimneys thrown down and buildings injured.

(*c.*) Origin in Cook Strait, north-north-east of Stephen Island, about ten miles wide, and apparently traceable with few interruptions nearly to mouth of Wanganui River; depth, fifteen miles or more. More than half the earthquakes recorded in New Zealand belong to this region; earthquake of 8th December, 1897 (VIII to IX, R.-F.), and other severer ones come from south-south-west end.

(*d.*) An origin near Mount Tarawera, with a large number of moderate or slight shocks, most, but not all, volcanic and local in character—*e.g.*, those of September, 1866, and those of June, 1886, which accompanied and followed the well-known eruption of Mount Tarawera.

These origins of Group IV, (*a*), (*b*), (*c*), (*d*), are nearly in a straight line on the map; on or near the same line are the origins of earthquakes felt in the Southern Lake district (15th December, 1883, &c.), the volcanoes Ruapehu, Ngauruhoe, Tongariro, Tarawera, and White Island. It is evident that this line, which, like the rest, is parallel or nearly so to the general axis, is a line of weakness or of unstable equilibrium. Hence the adjusting movements that have caused earthquakes may have, from time to time, relieved the pressure of the rocks that restrained overheated steam and other volcanic agents from bursting out, and so may have led to volcanic eruptions; just as the series of earthquakes in Guatemala and in the Caribbean Sea in April and May, 1902, were the signs of movements in the great folds of that part of the earth's crust, in the course of which, the pressure in the Antillean Ridge being relieved, the volcanic forces below Mount Pelée in Martinique, and Mount Souffrière in St. Vincent, caused the disastrous eruptions of that year.

Group V.—Off the coast near Raglan and Kawhia. Chief shock: 24th June, 1891 (VII–VIII, R.-F.). The line joining this origin to that of the earthquake of 1st February, 1882, is parallel to the other lines of origins (Groups I to IV); but we have no data to establish any connection between them.

Art. LVII.—*Note on the Occurrence of Two Rare and Two Introduced Moths.*

By G. Howes, F.E.S.

[*Read before the Otago Institute, 14th November,* 1905.]

Plate XLIV.

Asaphodes parora.

This rare species not having been figured by Mr. Hudson, I have sketched from a specimen taken in August, 1900, at West Plains. Mr. Philpott has a specimen also from West Plains, and very much lighter in colour.

Xanthorhoe subductata.

I took a ♀ specimen of this moth in Dunedin in March, 1904. Mr. Hudson mentions *subductata* as occurring in Auckland in December. My specimen has ¼ in. more wing-expanse than that described by him, and the lines are fainter.

Achæa melicerte.

A splendid specimen of this grand Australian moth was sent to me by my brother from Motueka, Nelson. Caught in February or March of last year. With the two records, first in 1876 and then from Titahi Bay last year, this should place *A. melicerte* among oui established *Lepidoptera.*

Pyralis farinalis.

This moth has occurred very plentifully in Dunedin the last two years, and has apparently become fully established.

Art. LVIII.—*Some New Species of* Lepidoptera.

By G. Howes, F.E.S.

[*Read before the Otago Institute, 12th September,* 1905.]

Plate XLIV.

Physetica hudsoni.

♂, 42 mm. One specimen. Antennæ, legs, and face bluish-grey. Palpi bluish-grey, ochreous beneath. Crown ochreous-grey. Patagiæ grey margined with delicate blue. Abdomen ochreous, tinged with dark-grey dorsally. Anal tuft ochreous. Forewings light greyish-blue, all lines and markings as if pencilled on in darker colouring. Costa slightly arched, apex subacute, narrow suffusion along costa from base to apex. A very jagged transverse line close to base. A jagged transverse line at about $\frac{1}{3}$ and another at $\frac{2}{3}$, approaching each other in centre of wing, then bending sharply away and approaching again about centre of dorsum. A jagged transverse subterminal line, twice sharply dentate, near tornus. A clouded dark suffusion between this and line at $\frac{2}{3}$ along costa. Portions of veins lightly outlined with darker scales. An undefined yellowish suffusion from costa to dorsum at centre of wing. Reniform obscure. Orbicular faintly shown, being lighter in colour than wing-centre. Cilia of forewings bluish-grey, slightly barred with grey. Hindwings bright-ochre, deepening to dark-fuscous towards termen, edging of dull-ochre along costa. Cilia long, ochreous-grey, with a faint fuscous basal line appearing very light by contrast with the darker cilia of the forewings.

This exceedingly beautiful moth was taken by Mr. Robert Gibb at Tuturau, near Mataura, attracted by light.

I am naming this moth after Mr. G. V. Hudson, as a slight recognition of the great good his entomological work has been to the southern workers.

Melanchra beata, n. sp.

♀, 38 mm. One specimen. Legs, antennæ, palpi, and face all reddish-brown. Thorax greyish-brown. Abdomen dull-grey, reddish below. Anal segment reddish. Forewings: Costa slightly sinuate at about $\frac{1}{3}$. Apex subacute. Termen sinuate near tornus and oblique. General ground-colour delicate pinkish-brown. Three pairs slight dark marks on costa. A series of small obscure black dots along termen. Orbicular faintly outlined in white, broadly oval, oblique. Clariform triangular, posteriorly outlined in white. Reniform outlined in white. A faint light-brown irregular line near termen, ending in a blackish three-cornered blotch close to tornus, margined on terminal side with white. Cilia light-brown. Hindwings light-brown, deepening towards apical portion and towards dorsum. Cilia dark-brown edged with white.

Taken at blossom in November in bush at Ototara, near Invercargill.

Agrotis veda, n. sp.

♂, 30 mm. One specimen. Antennæ dark-fuscous, bipectinated. Palpi light-grey, with dark terminal joint. Thorax grey, extra pubescent beneath, tufts prominent. Head and anterior crest dark-grey. Abdomen silvery-grey. Slight anal tuft. Forewings silvery-grey, with a slight red suffusion. Reniform and orbicular are joined and outlined in brown, but not complete. A series of slightly darker markings between veinings of forewings. An interrupted brown line showing on costa at $\frac{1}{3}$, and again at centre of wing, and as a faint mark on dorsum. Cilia grey. Hindwings grey, with faint darker terminal suffusion. Discal spot crescentic, fuscous. Cilia greyish-white.

From Motueka, Nelson.

Leucania obsoleta.

♀, 37 mm. One specimen. Antennæ ochreous, filiform. Legs and palpi greyish-ochreous. Legs fuscous beneath. Face and thorax dark-ochre. Thorax moderately crested. Abdomen dull-grey; anal segment paler. Forewings uniform light-ochre. Veins plainly outlined in grey. Orbicular and reniform obsolete. Slight dark shading from base to half-way along wing-centre. Termen very slightly sinuate near apex. Hindwings uniform fuscous, with cilia light-ochreous as in forewings.

This moth appears to be close to *L. arotis*, but differs in coloration, in the absence of dots on the forewings, and in its pale-ochre cilia.

Taken in December in Dunedin.

EXPLANATION OF PLATE XLIV.

Fig. 1. *Physetica hudsoni.*
Fig. 2. *Melanchra beata.*
Fig. 3. *Agrostis veda.*
Fig. 4. *Melanchra phriceas.*
Fig. 5. *Leucania obsoleta.*
Fig 6. *Asaphodes parora.*
Fig. 7. *Xanthorhœ subductata.*
Fig. 8. *Achæa melicerte.*
Fig. 9. *Pyralis farinalis.*

Art. LIX.—*The Effect on Temperature of Molecular Association and Dissociation.*

By S. Page.

[*Read before the Philosophical Institute of Canterbury, 6th September*, 1905.]

In this paper it is proposed to show that in certain chemical reactions much of the temperature-change may be due to a source overlooked in Berthelot's fundamental proposition as stated in 1879—viz., "The heat disengaged in any reaction is a measure of the chemical and physical work done in that reaction." In recent criticism of Berthelot's proposition this source appears to remain unnoticed.

According to the kinetic theory the temperature of any given gas is proportional to the mean square of the molecular velocity, and for different gases the temperature is proportional to the average kinetic energy of translation of the molecules.

If we mix equal volumes of two different gases without any temperature-change resulting it can be shown that $mnv^2 = m_{\prime}nv_{\prime}^2$, where m and v represent the mass and average velocity of the molecules in the one, and $m_{\prime}$ and $v_{\prime}$ the corresponding quantities in the other, gas. That is to say, at the same temperature the average kinetic energy of translation of all gaseous particles must be the same whatever be their masses.

If we have two gases with molecular masses of m and $\frac{m}{2}$ respectively, then, where their average molecular velocities are equal, their respective kinetic energies are as 2 : 1, and their respective absolute temperatures therefore as 2 : 1. Let us apply this, in the first instance, to those numerous cases in which gaseous molecules when heated split up into two or more parts, reassociating on cooling—*e.g.*, water, carbon-dioxide, ammonium-chloride, nitrogen-peroxide, &c. The dissociation absorbs heat, while the reassociation, promoted by cooling, gives out heat.

Consider the case of N_2O_4—nitrogen-peroxide: If this gas be heated above 0° C. some of the molecules split into two parts, as is shown by the lessened density. Disregarding any work done in bringing about this disruption, and further neglecting, for the present, any change in the *internal* energy of the molecule, we may fairly assume that the sum of the kinetic energies of translation of the two parts must be equal to the kinetic energy of translation of the original molecule. But each part is now an independent molecule, having half the kinetic energy of translation of the molecules around it. So mv^2 has become $2 \times \frac{m}{2} v^2$, and therefore each NO_2 molecule in impact with the rest will have its velocity increased, and will not be in equilibrium until its original velocity is doubled; for $\frac{m}{2}v_{\prime}^2$ to be equal to mv^2, $v_{\prime}^2$ must be equal to $2v^2$. In other words, heat will be absorbed by the dissociation. Each molecule that dissociates is thereby reduced to half its original absolute temperature, if the term "temperature" can be applied to individual molecules.

The internal energy neglected above may be a disturbing factor. If the sum of the internal energies of the two new molecules is less than that of the original molecule, the difference will be added to the external translation energy, and the fall of temperature may be less than given above.

As for the *quantity of heat* which appears or disappears in any given case, this will obviously depend upon the initial temperature, increasing and decreasing with it. For instance, in the oxidation of CO into CO_2 the number of molecules decreases by one-third, the kinetic energy of the vanished molecules is divided amongst those which are left, and hence, neglecting any heat produced by chemical attraction, or absorbed as internal energy in the more complex new molecules, the temperature will rise one-third. Supposing the initial temperature to be 600° C., the final temperature will thus be 800°, a rise of 200° which does not represent any chemical or physical work done in the reaction. If by the use of catalytic agents or otherwise the reaction could be carried out at a temperature of 60° the rise would be 20° only. If, on the other hand, the reaction could take place in an arc lamp at, say, a temperature of 3,000° C., the rise of temperature would be 1,000°. The quantities of heat disengaged would be proportional to the temperature-rise. Hence it would appear that heats of combustion of gases, in all cases where the number of molecules alters, should vary with the initial temperature of the experiment, and should be affected also by any rise of temperature during the experiment. A difficulty in calculating the amount of this effect in any given case may arise in this way: In reactions accelerated by heat those molecules with velocities above the average may suffer change more readily than the rest, introducing an uncertainty as to the true initial temperature.

If a gaseous molecule could be split up into parts small enough, the temperature of these parts might be reduced nearly to absolute zero without any reduction of molecular velocity. Supposing, for example, the alpha particle separated from a molecule of radium at 0° C. to have a mass of $\frac{1}{100}$ of the original molecule, and to split off without gaining or losing velocity, its kinetic energy would be $\frac{1}{100}$ of that of the original molecule, and would correspond to a temperature of 2·73° absolute. It would appear, then, that if association or dissociation could be carried on sufficiently far in a given mass, the temperature of that mass may alter to any extent, its kinetic energy remaining the same. As, approximately, the specific heat of gases under constant pressure is inversely proportional to their densities, any dissociation should proportionately increase the specific heat.

Reasoning similar to the foregoing can be applied to liquids, though with less certainty, and perhaps also to solids. Assuming it to be thus applicable, and neglecting the internal-energy factor, the following relations should hold :—

1. Whenever, in a given mass undergoing chemical change, there is an increase or decrease in the number of molecules, there is a proportionate decrease or increase of the absolute temperature.

2. The temperature of a given mass may be altered apart from external conditions, thus : (*a*) by conversion of potential energy of chemical affinity into kinetic energy, and *vice versa* ; (*b*) by conversion of internal energy of a molecule into external energy, or *vice versa* ; (*c*) by association or dissociation of molecules, including ionization ; (*d*) by dissociation of atoms, as in radium.

3. The temperature of a given mass remains proportional to the sum total of the kinetic energy of translation of its particles only so long as the number of particles remains constant.

4. Evolution of heat in a chemical reaction is not necessarily synonymous with production of energy, but may be due merely to the distribution of the original energy amongst a greater or smaller number of molecules.

The displays of light and heat so familiar in cases of chemical combination suggest the idea that chemical actions take place only when heat is evolved by them. This idea was given definite expression by Thomsen, and later by Berthelot, thus : "Substances which can act chemically upon one another tend, when left freely to their mutual action, to produce that system which is formed with the greatest evolution of heat." This statement, however, has been found to be much too general, and is no longer defended in its entirety, many cases being known in which heat-absorbing reactions occur spontaneously. On examining some of these endothermic reactions, however, it will be found that there is quite a possibility that they are really exothermic after all, so far as the chemical reactions are concerned. Some, if not all, of the apparent loss of heat is obviously due to increase in the number of molecules—*e.g.*, solid Glauber's salt mixed with concentrated hydrochloric acid liquefies spontaneously, and cools down many degrees. On writing the equation a large increase in the number of particles becomes evident—$Na_2SO_4 . 10\,H_2O + 2\,HCl = 2\,NaCl + H_2SO_4 + 10\,H_2O$. Allowing for ionization, there is an increase of particles in the ratio of about 17 to 5. Hence, even though the transformation be far from complete, there is a considerable increase in the number of molecules, or ions and molecules, and therefore a considerable decrease in temperature, quite apart from that due to chemical energies.

In connection with Van't Hoff's finding that the principle of maximum work stated by Berthelot is the more nearly correct the nearer the temperature of reaction is to absolute zero, and that at absolute zero it would be correct, it is perhaps worth pointing out as a coincidence that the apparent heat-changes due to formation or disappearance of molecules become proportionately less as the temperature of reaction is lowered, and vanish at absolute zero.

If the temperature of solids is proportional to their molecular kinetic energies, then, neglecting the internal-energy factor, the capacity for heat of equal numbers of molecules should be the same irrespective of their masses. Hence the specific heat of solids (other things being equal) should be inversely proportional to their molecular weights. The specific heats of the solid elements, however, are proportional to their *atomic weights*, which suggests that the solid elements with normal specific heats have the same number of atoms per molecule.

ART. LX.—*The Resistance of Steel to Mechanical Shock, and the Determination of Material suitable for Machinery.*

By Professor SCOTT, Memb.Inst.C.E., Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 2nd August,* 1905.]

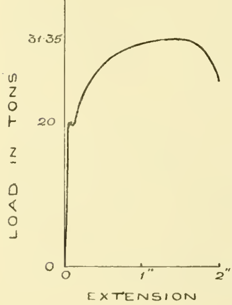
FROM the earliest days the worker in steel has applied some test to insure that his labour might not be expended on worthless material. The blacksmith tests the quality of the iron he uses by nicking and breaking over the anvil, being guided to his conclusions by the force of the blows necessary to effect the fracture, and by the appearance of the broken surface. This test, crude as it may appear, is, in the hands of an experienced man, a more reliable indication of the suitability of the material for the manufacture of machine-parts than many of those tests which it has been customary for engineers to specify, and which entail the use of a large and expensive plant. In fact, this test, in a standardised form, is an accurate measure of the relative capacity of metals for resisting "shock."

The introduction of the systematic testing of the materials of construction is of very recent date, and had its origin in the experiments on the strength of structures so often made by engineers in the early part of the last century, and rendered necessary by the development of important works at a more rapid rate than the theory of applied statics and dynamics. As the theory developed, cumbersome full-sized experiments were replaced by those on models, when it became evident that if the physical properties of the material were accurately known experimental work would in ordinary cases be unnecessary

Machines had been made for the proof testing by "pulling" of chain cables, suspension-links, &c., and only trivial modifications in design were required for the production of smaller appliances suitable for testing specimens of the material it was proposed to use. A period of refinement brought the sensitiveness of such machines up to 1 in 20,000, and instruments capable of measuring extensions as small as $\frac{1}{200000}$ in. were constructed. With these it was ascertained that on being progressively loaded a bar of iron or steel is practically elastic up to a point of loading known as the "elastic limit," and imperfectly elastic up to a further point known as the "yield-point"; at this point it suddenly breaks down, extending rapidly without further loading, then hardens, and the extension increases with—but more rapidly than—the load, being partially "elastic," but for the most part "plastic," until the point of maximum load is reached, when the material begins to flow, contracting rapidly until it fails at a lower total load than the maximum, but at a greater stress per unit. of the now reduced cross-section.

This behaviour is most readily shown by means of a diagram, similar to that drawn by the autographic recorder with which most testing-machines are equipped, in which the co-ordinates represent the extension of, and the corresponding load upon, the tested piece.

Fig. 1.



In such a test the ultimate and elastic strengths of the material are obtained, together with its extension and contraction of area; the latter are measures of its ductility. The test usually required by engineers is of this description, and must satisfy certain specified values.

In quite the early days of tensional testing it was noticed that metal which had given excellent results on test often failed under a comparatively low load in service, and that such failure occurred when the load, or some portion of it, was a live one. It might naturally have been expected that if the stress engendered by a live load exceeded the elastic strength of the material, failure must eventually result from the accumulated plastic extensions; if, on the other hand, the elastic limit was not reached, that the piece would be safe. Many failures, however, occurred in which by no method of computation could the material be shown to be loaded above its elastic strength.

This apparent anomaly led Wöhler and subsequently Bauschinger and others to investigate the effect of repeated and alternating stress, or, in other words, of "fatigue," on materials. These investigations have resulted in establishing that the "physical constants" of a bar are the cumulative result of its "life history," and that its elastic limit may be artificially raised by overstrain or cold rolling, but that such an elastic limit is exceedingly unstable, and may be reduced to a very low value, or even zero, by heating, hammering, or alternation of loading. It can be seen, therefore, that failures by repeated loading within the nominal elastic limit may be explained by the assumption that the limit was an unstable one.

Further, Wöhler and Bauschinger found that with gradually applied repetitory or alternating loads the range of stress which the bar is worked over is the principal factor in its endurance—the smaller the range, the greater the load which can be carried — and that the relationship between the statical breaking-strength (t), the breaking-strength when the load is altogether removed and again reapplied an unlimited number of times (u), and the breaking-strength when the load is completely reversed (to the same magnitude but opposite sense) an unlimited number of times (s), is $t : u : s :: 3 : 2 : 1$.

Many formulæ have been devised to fit the results of these experiments. Gerber showed that if the minimum stresses were plotted as abscissæ, and the corresponding limiting ranges of stress as ordinates, the points fell upon the curve of a parabola.

On the basis that many of Wöhler's experiments gave the ratio of $t : u : s :: 3 : \frac{3}{2} : 1$, Launhardt and Weyrauch constructed equations, the former for the limiting ranges of repetitory, and the latter for the limiting ranges of alternating, loading. These formulæ have been very generally used, but on plotting the results given by them it will be found that the curve is non-continuous, there being a change of direction at the one stress zero-point. There are also other anomalies.

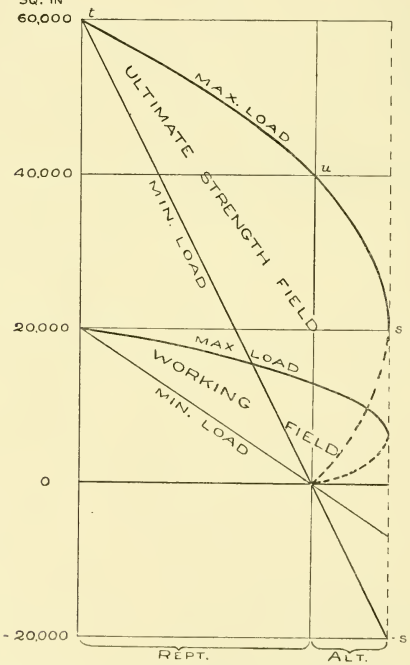
Some years ago the writer discovered that if the more correct values of the relationship of t, u, & s of $t : u : s :: 3 : 2 : 1$ be adopted, the equations of Launhardt and Weyrauch reduce to the common form of

$$a = \tfrac{2}{3}t\left(1 + \tfrac{1}{2}\frac{\text{L min.}}{\text{L max.}}\right)$$

This formula may be always used when the statical breaking-strength (t) of the material is known, and gives, in terms of the ratio of the least (L min.) to the greatest (L max.) load on the piece, the limiting stress (a) per unit of cross-section.

In applying the formula to arrive at the safe working-stress (b), a factor of safety (say, 3) should be adopted. Further, this formula fits intermediate experimental results, and if the minimum stresses be plotted as abscissæ and the corresponding ranges of stress as ordinates the points lie upon a parabola.

Fig 2.

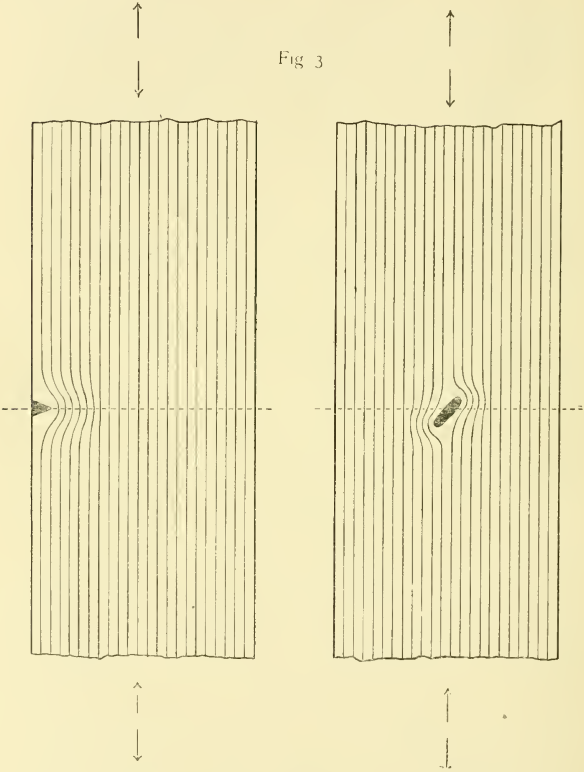


For some years after the publication of Wöhler's researches it was believed that the problem of the working-strength of iron and steel had been satisfactorily solved; but the frequent failure of material of presumably stable elastic limit within the ranges of stress prescribed as safe soon raised a feeling amongst engineers that the theory was incomplete, the more so that test specimens cut from close to the plane of fracture usually gave normal elongation, contraction of area, and elastic limit. (The writer has himself tested with such results many samples from fractured gun-mountings, drawhooks, chains, crank-pins, piston-rods, &c.). To account for such failures, the theory was advanced that the fatigue had been localised on planes of such minute thickness that their influence on the physical constants of the specimen was so small as to escape detection in ordinary testing. It was pointed out that the presence on a stressed piece of an initial, scratch, flaw, or tool-nick must lead to a crowding of the stress-lines in its immediate neighbourhood which might easily result in overstrain there; with repeated loading the portion so overstrained must eventually fail, and a further crowding of the stress-lines and a further development of the flaw take place, and in this way progressive fracture would ensue. (See fig. 3 on next page.)

Now, although this may happen, this theory in no way accounts for the fact that material which has given most excellent results under tension test sometimes fails after having been in service for a period far too short for fatigue fractures to develop. In fact, the failure of a number of steel plates by falling a few feet from a crane-sling, after strips cut from them had given normal results in the testing-machine, led to the important discovery by Mr. Seaton that these otherwise unaccountable failures only occur when the piece is subjected to "shock," and that the capacity of steel to resist shock—or, in other words, its anti-brittleness—appears to be in no way guaranteed by the passing of a satisfactory tensional test.

Pure carbon steel may be considered to be a solid solution of carbon in iron, and its principal properties can be illustrated in no better manner than by the commonly used analogy of the behaviour of solution of common salt in water. Guthrie has shown that by the addition of salt to water its freezing-point is lowered: the larger the percentage of salt up to about 23·5 per cent. the lower the freezing-point; for water containing 23·5 per cent. of salt it is 22° C. If there be less than 23·5 per cent. of salt in solution, on the temperature being lowered ice-crystals will first form; a portion of the water thus crystallizing out, the solution becomes stronger, and a further lowering of the temperature is required before further crystallization can take place. In this way the percentage of salt in the residual solution is increased as the temperature is lowered, until − 22° C. and 23·5 per cent. of salt is reached; at this point the water and salt crystallize out side by side, forming the cryohydrate or eutectic of salt and water, and the result is evidently crystals of pure ice surrounded by the crystals of the cryohydrate.

Fig 3

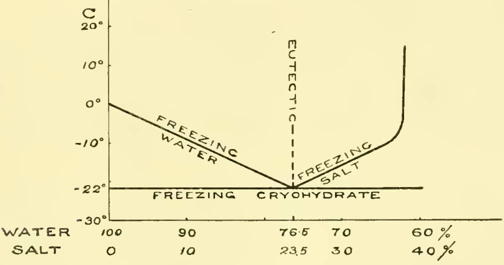


On the other hand, if the percentage of salt originally in solution were greater than 23·5 per cent., on the temperature being lowered salt-crystals would first form, and the solution being thereby weakened, a further lowering of the temperature would again be required for a further deposit of salt-crystals to occur, and this action would continue until — 22° C. and

23·5 per cent. of salt was reached, when, as before, the salt and ice crystals would separate out side by side, forming the intimate mixture, the cryohydrate or eutectic; but in this case we should have crystals of pure salt surrounded by crystals of the eutectic.

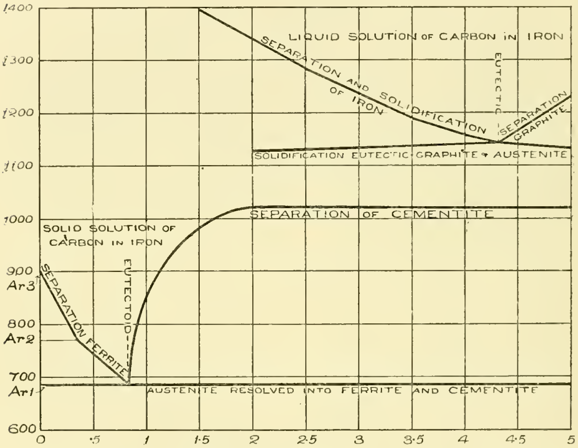
At each stage of the solidification there would be a retardation in the fall of the thermometer, which on reaching — 22° C. would remain stationary till the whole mass solidified. It is evident that for all mixtures other than 23·5 per cent. there are at least two distinct retardations—the first, dependent on the strength of the solution, occurring when the crystals of ice or salt commence to separate out; the second, when the formation of the eutectic begins. Where the solution is originally of eutectic proportions (23·5 per cent. of salt) only the latter point of retardation occurs, there being no crystallization until — 22° C. is reached. (The matter may be made clear by reference to fig. 4.)

Fig 4



Now, the behaviour on cooling of a liquid solution of carbon in iron is very much that of the salt-in-water solution—if there is less than about 4·5 per cent. of carbon present we have first the separating-out of the iron, and then the solidification of the eutectic of iron and carbon. If there is more than 4·5 per cent. carbon present in the liquid solution the graphite first separates out, then when the temperature has fallen sufficiently the eutectic, the solution being by this time of euctetic proportion. If originally of eutectic proportion (4·5 per cent. carbon) there is only one point of retardation and solidification. But there is this great difference between the ice and the iron: the latter, on account of the high temperature at which it solidifies, retains a certain amount of carbon after it becomes solid. Hence there is a solid solution of carbon in iron which introduces further changes after the iron has cooled to a temperature at which it is no longer capable of retaining dissolved carbon as such. This explains the existence of somewhat similar curves in the lower portion of fig. 5.

Fig 5



In this solid solution, with changes of temperature actual changes of structure take place, and on cooling crystallizing-out of its constituents occurs, accompanied with characteristic retardation of fall of temperature. The loci for varying proportions of carbon of such retardations, known as the Ar_3 point, the Ar_2 point, and the Ar_1 point, are shown by the lower curves on the figure.

Taking a steel of, say, 0·15 per cent. carbon at a temperature of 1,000° C., such steel at that temperature will be in the form of a solid solution of carbon in iron ; allowing it to slowly cool, on its temperature falling to about 850° C. pure iron will separate out in the form of ferrite-crystals—in much the same way that the ice-crystals formed in the water-and-salt solution. This action will go on until the temperature has dropped to about 760° C., when a second point of retardation marks a magnetic change in the iron.

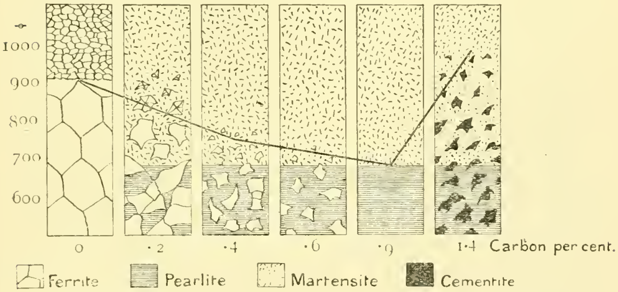
Crystallization out of the ferrite still continues until at a temperature of about 680° eutectic proportions are reached. At this the critical point, Ar_1, the carbon, in the form of the carbide Fe_3C, separates out alongside the ferrite, forming the eutectic of iron and carbide of iron known as " pearlite." We thus have as the final condition of our material ferrite-crystals imbedded in a matrix of pearlite which itself consists of an intimate mixture of iron and carbide of iron.

When the steel contains above 0·35 per cent. of carbon the Ar_3 and Ar_2 points are merged in one.

A steel containing 0·9 per cent. of carbon is of eutectic proportions: there is consequently only one point of retardation—the Ar or carbon point, at 780° C.—and no separating-out of ferrite crystals, the resulting steel being wholly pearlite. If the steel contains more than 9 per cent. of carbon, still following the analogy of the salt-and-water solution, the carbide Fe_3C (cementite) first forms, then the pearlite, and the resulting steel consists of cementite in pearlite with no free ferrite-crystals.

If a steel, instead of being slowly cooled, is quenched from a temperature the value of which is disputed, but which the writer considers it rational to suppose should be just above the Ar_3 point, and hence dependent on the percentage of carbon, no time is given for the changes, indicated by the curves, to occur, and the material is retained in practically the same state as it was in at the quenching-temperature, the carbon remaining in its diffused or hardening condition. Steel so treated is fully hardened. To such quenched steel the name of " martensite " is given; if of eutectic proportions, " hardenite."

Fig. 6.



The diffusion of carbon in steel has never been better illustrated than by an experiment performed last year by Mr. Stead. Six bars of varying carbon content were made coarsely crystalline by very slowly cooling down in the heart of a ladle of molten blast-furnace slag. Then all of them were heated at one end to a little above 1,000° C. and kept comparatively cool at the other extremity. The temperatures at equal intervals along the bars were measured by a Chatalier pyrometer. After heating until the temperatures were constant each bar was quenched in cold water, ground bright, polished, and etched, and micro-photographs prepared. Fig. 6 shows the result.

In the case of *No. 1 bar* (pure iron) there is no apparent change of structure until a temperature of 870° C. is reached. Then reorganization is apparent, the crystals becoming smaller.

No. 2 Bar (0·2 per cent. carbon).—In proportion as the temperature has exceeded 750° C. so the carbon has diffused from the carbide areas (pearlite) into the surrounding ferrite, until at about 1,000° C. the diffusion is complete (martensite). It will be noticed also that the breaking-up of the ferrite-crystals occurs, as before, at the Ar_3 point.

No. 3 Bar (0·4 per cent. carbon).—Diffusion is complete at about 830° C.

No. 4 Bar (0·6 per cent. carbon).—Diffusion is complete at 770° C.

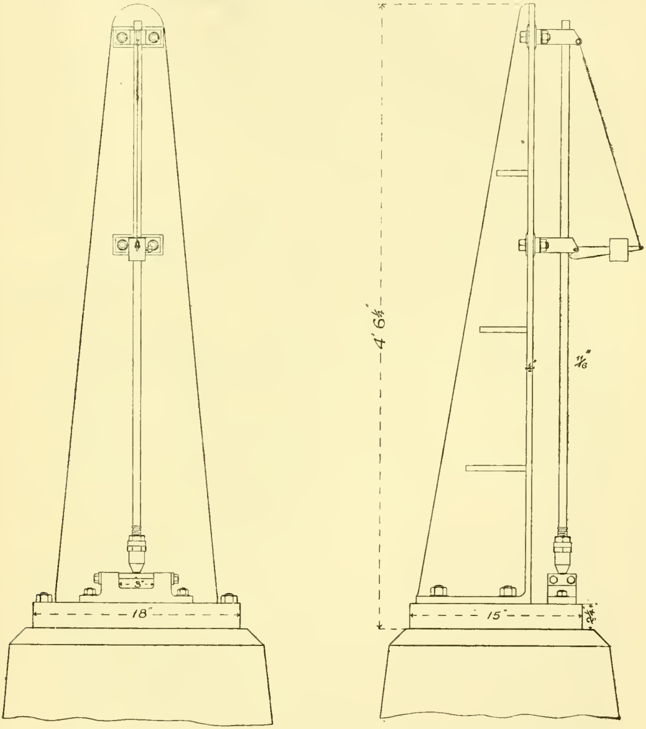
No. 5 Bar (pure pearlite (saturated) steel which contains 0·9 per cent. carbon).—Diffusion or solid solution is complete at Ar_1 point, 690° C.

No. 6 Bar (1·4 per cent. carbon). — The excess of cementite shows here. Diffusion is complete at 1000° C. (Ar_3 point).

On the figure the writer has drawn lines, the loci of the Ar_3 points, for the different percentages of carbon contained in the bars, and it is remarkable to note how nearly this comparatively rough experiment of Mr. Stead's agrees in each case with the theoretical point of diffusion.

From the foregoing it will be seen that steel, instead of being the homogeneous material it is popularly supposed to be, in reality partakes more of the nature of a crystalline rock; and this is especially true of the normal low and medium carbon steels so much used for constructive work and machine details. When the complex nature of its structure is taken into consideration it appears probable that such steel may break in more than one way; and apparently this is the case, for when broken by a gradually applied tensional or repeated or alternated load there are invariably present in the neighbourhood of the fracture the slip planes between the particles first noticed by Professor Ewen and Mr. Rosenhain, but slip planes have not been found in any case where the fracture has been due to shock.

That capacity to resist shock is a property distinct from that of resistance to progressive loading is shown by the following tables of the results of experiments conducted by Mr. Seaton, Captain Sankey, and the writer. The impact test adopted by Mr. Seaton consists in allowing a tup of 6 lb. weight to fall through 2 ft. on a notched specimen, of square section, $\frac{1}{2}$ in. side, placed on a span of 3 in., the specimen being turned over after each blow, its resistance to shock being measured by the number of blows required to produce fracture. The author has designed and had constructed a machine for carrying out the same test. This tester is illustrated by Fig. 7.



The machine used by Captain Sankey is on the Charpy principle as modified by Izod. A comparatively frictionless pendulum with light rod and heavy bob is allowed to fall freely to the bottom of its swing, where it encounters a notched specimen, the work done breaking which is readily obtained, as the angular distance by which the pendulum fails to rise to the height which it attains when swinging freely is recorded by a pointer.

The following tables are extracted from results published by Messrs. Seaton and Jude and Captain Sankey. (The experiments at Canterbury College are not yet complete. They will appear as a supplement to this paper).

SEATON AND JUDE (TABLE I).*

—		Tension, 3 in.	Elongation per Cent. on 2 in.	Impact: Blows.
Cold-drawn bar, less than 0·1 per cent. carbon steel	*a*	31·63	31	1
	b	31·27	20	180
Low-carbon steel, 0·15 per cent. carbon	*a*	28·3	37	175
	b	27	33	5
Medium-carbon steel, 0·25 per cent. carbon	*a*	36·5	35	5
	b	36·5	35	27
Mild cast steel, 0·35 per cent. carbon	*a*	29·18	22·7	1
	b	28·25	31	1

* "Impact Tests on the Wrought Steels of Commerce" (Proceedings Mech. Engrs., 1904).

SANKEY (TABLE I).

Description.	Treatment.	Maximum Load.	Yield-point.	Elongation on 2 in.	Reduction Area.	Impact.
					Per Cent.	Ft.-lb.
Studs teel	As received	34·7	21·6	21·5	52	1·3 (very short).
	Annealed..	28·1	21·4	36·5	58	21·2 (very tough).

SANKEY (TABLE II).

Material.		Maximum Load.	Yield-point.	Elongation on 2 in.	Impact.
					Ft.-lb.
Steel for small forging ..	1	43·2	31·8	23·5	8·6
	2	45·2	32·7	23·0	1·0
Steel for crank-shaft.. ..	1	30·8	14·8	30·0	0·9
	2	28·7	13·2	32·0	4·8
High tensible steel	1	60·1	49·8	18·0	18·5
	2	61·8	51·3	16·0	0·5
Steel for small crank-shaft ..	1	26·0	..	38·0	2·3
	2	24·8	..	35·0	16·4
Steel for small forgi ~ ..	1	39·4	..	28·0	3·0
	2	40·3	..	32·0	13·4

That the impact test on notched bars is of marked value has been fully demonstrated by the clearing up by this method of testing of much of the mystery which has surrounded the results of the oil hardening and tempering of steel.

Oil tempering as generally practised for guns, axles, &c., consists in heating to about 850° C., then quenching in oil at 80° C., after which the material is reheated to between 550° and 650° C. By the first heating (to above the Ar_3 point) fineness of structure is obtained, and by the quenching retained. By the second heating (to below the Ar_1 point) any mechanical stresses due to the quenching are removed, the hardening carbon converted into cement carbon, but the fineness of structure is unaltered. Practice has proved that steel so treated is safe for gun-construction, and when not so treated unsafe. Yet the tension tests show only an increase of strength and ductility by oil tempering of something between 5 and 30 per cent.

The improvement in the material is out of all proportion greater than that indicated by these values; and Mr. Seaton, applying his test, finds that by so tempering, the impact strength of the steel, as measured by the number of blows required to produce fracture, is increased to between 500 and 600 per cent. of that of the untempered steel in its best condition.

Messrs. Seaton and Jude also find that oil tempering has the property of levelling up the "shock" strength of steel to a fairly constant quantity. Two articles may have been made from the same grade of steel: owing to difference of heat treatment in manufacture one may be coarsely crystalline and dangerously brittle, the other fine-grained and tough. Oil quenching will bring the shock strength of these up to a common value—the increase in one case being measured by thousands and the other only by hundreds per cent.

Since it would appear that the failure of steel members may be brought about by (1) statical overloading, (2) fatigue, (3) shock (the effect of which is apparently cumulative), it would seem rational that for all practical purposes material should be tested in the same manner as that in which it is to be loaded when in use. Thus, for structural work, where only a dead load is to be carried, a tensional test is sufficient, for from this in all but special cases the compressional, cross-bending, and shearing strengths can be computed. For structural work with gradually applied live load the tensional test is again required, as from this and the ratio of live to dead load the working-stress permissible, with security against fatigue, is obtained.

SEATON AND JUDE.—(TABLE II).*

Effects of Oil Quenching at about 800° C.

Description.	Normal Condition.				Analysis.	Oil quenched.		
	Impact: Blows.	Max. Load in Tons per Sq. in.	Elongation per Cent. on 2 in.	Condition.	Average per Cent.	Impact: Blows.	Max. Load in Tons per Sq. in.	Elongation per Cent. on 2 in.
Low carbon acid steel	7	..	..	..	C = 0·15	165	..	..
	5	26·9	29·8	As received	S = 0·032 to 0·056	159	25·7	31
	165	..	..		P = 0·033 to 0·023	177	..	..
	163	..	..	..	Mn = 0·63 to 0·75	181	..	..
					Si = 0·065 to 0·057			
Basic steel—								
Low carbon	293	23·2	46	As received	C = 0·11, S = 0·051; Mn = 0·45, P = 0·044	301	27·8	35
	217	26·3	40·5	As received	C = 0·17, S = 0·050; Mn = 0·65, P = 0·052	280	31·5	38
High carbon ..	1	55·7	12	..	C = 0·73, S = 0·056; Mn = 0·6, P = 0·053	5	74·4	3
Admiralty steel, medium carbon	23	32·5	35	As received	..	105	37·8	31·4
	35	..	..	Annealed in lime	C = 0·23	..	..	..
	35	..	..	Annealed in coke-dust	S = 0·036	..	..	..
Ordinary grade	5	..	..	As received	P = 0·058	111	..	..
	47	..	..	Annealed in lime	Mn = 0·76	..	..	..
	5	..	..	Annealed in coke-dust	Si = 0·05	..	..	..

* Proceedings Mech. Engrs., 1904.

Dangerous brittleness can be guarded against by the impact test. For rails, axles, ordinance, and all moving parts of machines and engines the impact test is of primary importance (it has been calculated that 85 per cent. of the parts of a modern high-speed engine are subject to shock); tensional tests must, however, also be made to obtain the data necessary for guarding against the effects of fatigue.

In conclusion it may be pointed out that no uncertainty need now exist as to the state of a fractured hook, chain, or machine part. A "shock" test will at once make clear whether the piece failed under overload, or was in a dangerously brittle condition. Further, the condition of existing parts and the rate at which the shock strength of axles, rails, tires, piston-rods, crank-pins, and chains is being used up can be readily ascertained, and the parts withdrawn from service before failure, possibly disastrous, ensues.

The object of this paper being to direct attention to and place in a condensed form some recent developments in the theory of steel, contemporary literature, such as "Harbord's Steel," and the proceedings of various scientific bodies, has been liberally drawn upon.

ART. LXI.—*The Portobello Marine Fish-hatchery and Biological Station.*

By GEO. M. THOMSON, F.L.S.

[*Read before the Otago Institute, 15th November,* 1905.]

Plates LV–LIX.

I. HISTORICAL.

ON the 8th October, 1895, the author, who had previously been in correspondence with Dr. Fulton, Scientific Superintendent of the Scotch Fishery Board, on the subject, read a paper before the Otago Institute on "New Zealand Fisheries, and the Desirability of introducing New Species of Sea-fish." In this paper the possibility of introducing the cod, the herring, the turbot, and the edible crab of Britain was considered, and the cost and style of the requisite buildings for a hatchery were outlined. After the subject had been discussed the desirability of establishing such a hatchery was affirmed, and a committee, consisting of Messrs. A. Hamilton, J. S. Tennant, and the author, was appointed to report on the best site for the proposed station. The committee handed in their recommendations at a meeting of the Institute held on the 12th May,

1896. It was considered that any place within Otago Harbour would be unsuitable and undesirable for the station, because "the whole area inside the Heads is systematically fished by seine nets and lines, and is liable to constant disturbance by traffic and harbour-works." Accordingly, attention was directed to the various inlets and bays near Dunedin, but outside the Heads, and Purakanui was selected as realising nearly all the conditions required. The report met with the hearty approval of the Institute, which appointed a committee, consisting of "Mr. A. Hamilton, Professor Parker, Dr. Don, Mr. F. R. Chapman, and Mr. Geo. M. Thomson, to confer with a committee of the Otago Acclimatisation Society and with members of both Houses of the Legislature, with a view to taking such steps as will lead to the establishment of a marine fish-hatchery at Purakanui."

On the 3rd June, 1896, a meeting of those referred to was held in the Town Hall, and was attended by the Hon. W. D. Stewart, M.L.C., the Hon. W. M. Bolt, M.L.C., the Hon. John MacGregor, M.L.C., James Allen, M.H.R.; Messrs. A. C. Begg and James Edgar, representing the Otago Acclimatisation Society; and Messrs. A. Hamilton and Geo. M. Thomson, representing the Otago Institute. It was felt that before the Government could be approached, more definite information on the scheme was required. The committee accordingly entered into communication with the American Fish Commission, and with Dr. Fulton of the Scotch Fishery Board, and the latter gentleman undertook to carry out experiments at the Dunbar Fish-hatchery with the object of ascertaining how long it would be possible to retard the hatching-out of the eggs of sea-fishes. The Otago Institute voted a sum of £10 to cover the expenses to be incurred in these experiments. Owing, however, to the transference of the Scotch Board's operations from Dunbar to the Bay of Nigg, near Aberdeen, these experiments were never carried out.

The whole question of the fish-hatchery was again brought up by the author in more definite form before the Institute and the Acclimatisation Society early in the following year (1897), and each of these bodies voted £250 towards the establishment of the station, conditional on the Government granting a similar sum for construction, and undertaking to carry on the station for a term of, say, ten years. It was felt that any work of the kind, though undertaken locally, was really a colonial matter, and deserved colonial assistance, hence the latter condition. About the same time Mr. G. M. Barr, C.E., kindly went down to Purakanui with the members of the committee and marked off the site suggested for the station.

In bringing this matter before the Government, the Hon. W. M. Bolt, M.L.C., and Mr. J. A. Millar, M.H.R., acted in co-operation with the committee, and during the session of 1897 the sum of £750 was placed on the estimates "and voted for fish-hatcheries and expenses of Expert Ayson to Canada and America." But in the letter sent to the author by the Marine Department it was added "that nothing will be done by the Government in the matter of establishing hatcheries pending the return of the expert."

The author wrote to the Marine Department on the 9th February, 1898, suggesting that the site marked out by Mr. Barr for the station should be set apart as a reserve, and accordingly in the *Gazette* of the 23rd September, 1898, there appeared a Proclamation setting aside "6½ acres in Purakanui Inlet as a reserve for a fish-hatchery." An additional sum of £250 was also placed on the estimates for "fish-hatcheries."

Mr. Ayson returned from his European and American trip early in 1899, and in the month of April came south to examine the site at Purakanui, and to report on the scheme. No doubt a report was sent in to the Department, but nothing definite was ascertained about it till, in reply to a question asked in the House by Mr. Millar, who moved for information as to the proposals of the Government, it was stated that "observations as to the summer and winter temperatures of the water at Purakanui were required before the scheme could be gone on with, and that steps for obtaining these were being taken." As a matter of fact, nothing was done in this matter, nor could anything of the kind have been undertaken without a very considerable expenditure, as there was no apparatus available, and no one on the spot to take observations.

Meanwhile, in December, 1899, Mr. Ayson came down again to Dunedin, and on the 8th met representatives of the Otago Institute and of the Acclimatisation Society in conference. The members present were Professor Benham, Messrs. A. Hamilton and Geo. M. Thomson, representing the Institute; Messrs. J. P. Maitland, T. Brown, A. C. Begg, and D. Russell, representing the Acclimatisation Society; and Messrs. J. F. Ayson (Inspector of Fisheries) and D. H. Hastings (local Inspector), representing the Government. The history of the movement from its inception up to the date of the conference was narrated by Mr. Thomson, who further stated the objects and requirements of the proposed station, as follows:—

Objects of the Establishment.—(1.) To institute scientific investigations on the marine fish fauna: (*a*) Physical—viz., temperature and density of the sea at various seasons, depths, &c., currents, &c.; (*b*) biological—viz., study of the development and life-history of the local fishes, their food-supply, &c., also of the marine invertebrate fauna. (2.) To collect and hatch out eggs of various local marine fishes and to distribute them. (3.) To introduce and rear desirable species of foreign fishes, as well as lobsters and crabs.

Buildings required.—(*a.*) One or more tidal ponds in which to place any fish, native or introduced, while under observation and investigation ; (*b*) spawning-pond for ripe fish ; (*c*) a building to serve as a fattening and spawn-collecting chamber ; (*d*) a hatching-house containing boxes, &c., in which the ova were to be hatched out ; (*e*) tank-house fitted with boiler, engine, and pump ; (*f*) laboratory. The estimated cost of these buildings, erected on the same scale as those of the Scotch Fishery Board at their Dunbar establishment, was £550. A curator's house, with rooms added in which students and experts who were engaged in research work could be accommodated, would also be required.

Control. — It was suggested that the Professor of Biology for the time being in the University of Otago be appointed by the Government as the honorary scientific director of the establishment, and that he be aided by a Board of, say, six members—two nominated by the Government, two by the Otago Institute, and two by the Acclimatisation Society—such Board to be elected annually or for such periods as the Government may decide, and to report annually to the Minister at the head of the Marine Department.

After considerable discussion Mr. Thomson's memorandum was unanimously agreed to, and Mr. Ayson expressed the opinion that the Government would do everything in its power to help the two contributing bodies in the movement towards the establishment of the hatchery and biological station.

Up to this point the Purakanui site alone was under discussion and consideration; but, apart from the difficulty which was experienced in getting to and from the spot and the time involved in visiting it, a serious drawback was noted which caused the abandonment of the project as far as this site was concerned. It was found that after periods of heavy rainfall the salinity of the water, especially on the ebb tide, was so very much reduced that it might prove fatal to any stock of fish—particularly deep-sea fish—which might be kept in confinement there. Accordingly a further examination of the coast was made for a new site, and in spite of the original objection urged against any spot inside the Heads the site at Quarry Point, Portobello, was ultimately fixed upon.

Nothing was done towards advancing the movement during the early part of 1900, for Mr. Ayson and some members of the local committee were occupied for a considerable time with an experimental trawling cruise in the small chartered steam-trawler "Doto." The coast round Stewart Island, along the east coast of both Islands as far north as Hauraki Gulf, and through Cook Strait to Nelson, was more or less examined. On this cruise three members of the committee gave scientific assistance—viz., Messrs. Hamilton, Thomson, and Professor Benham. But correspondence was carried on between the author and the Marine Department, the latter being very slow to make any forward move.

In reply to a question asked in the House of Representatives on the 17th August by Mr. J. A. Millar, the Minister of Marine stated that the £500 voted by the Government was available for the building if the Otago Institute and the Acclimatisation Society liked to go on with the work. Mr. Millar pointed out that this could not be done, as these bodies would be saddled with the cost of maintenance, which he contended would be unjust, seeing that the work was a national one. The Minister added that the Government proposed now to place £500 on the estimates for the building, with the addition of £250 a year for five years for the maintenance of the hatchery.

Meanwhile negotiations were commenced to secure the land required at Quarry Point, this being part of a reserve granted for a term of years to a Library Trust, and leased to Mr. A. Porterfield.

Difficulties also arose as to the purity of the water at the site selected, but these were set at rest by analyses made by Mr. W. Montgomery, which showed that it was practically as pure as ocean water.

The Minister also objected to the control passing from the hands of the Government to a nominated Board, seeing that the maintenance of the station was to be provided by the Government. This matter of control still formed the subject of discussion, and led to continued delay right on through 1901. Meanwhile the Government asked for, and received on the 15th June, plans and sketches of the buildings, &c., suggested as necessary. These plans were, of course, only approximations, as their shape and position would necessarily depend on the ground available, some of which had to be cut down and filled in.

In the beginning of September Mr. Ayson came down to Dunedin, and in company with Professor Benham and the author (representing the Institute), and Messrs. A. Stronach and D. Russell (representing the Acclimatisation Society), the location of the various buildings required at the Portobello site was agreed upon.

The following extract from a letter written by the author to the Secretary of the Marine Department on the 7th September, 1901, shows the unsatisfactory position of those who were urging this matter on the Government: "There is one important detail which I desire again to bring under your notice. None of those who interested themselves in this business have any status whatever. We come and go at our own expense, we advise as to work, plans, &c., but we have no authority to do anything. If the Minister would form a Board, as suggested, with as many Government nominees as is thought desirable, we would know exactly where we stand; at present we are only so many private individuals who are consulted by courtesy of the Minister and the Marine Department."

The proposals submitted to the Minister were sent down to the Public Works Department, Dunedin, and, after the site had been carefully surveyed, the District Engineer reported to Mr. Ayson that he found "that the works are entirely beyond your means. To give effect to your proposals will cost between £2,500 and £3,000." This was in October, 1901, and a little later a detailed estimate was prepared by the District Engineer giving the cost of construction at £3,000. This seemed to put a stop to the whole scheme, but the author was so satisfied that this was excessive that when Mr. Ayson came down to Dunedin in January, 1902, he went over the details with him, and got approximate estimates from outsiders showing that, even on the plans submitted, the work could probably be done for £1,500. Further, by reducing the scale of the work to be undertaken, it was estimated that the cost of construction might be brought down to £1,135.

This view of the matter was pressed upon the Minister of Marine, and practically accepted by him, as the following extract of a letter from the Department, dated the 13th March, 1902, shows: "I have the honour, by direction of the Minister of Marine, to state that there is no authority at present to appoint a Board of management with a legal standing, but it is proposed to set up an honorary advisory Board for the purpose of advising the Department upon any matters concerning the hatchery, it being clearly understood that the cost of establishing the hatchery in working-order must not exceed £1,100, and that the annual working-expenses must not exceed £250. The Board will advise the Department as to the expenditure of the above amounts, but will not incur expenditure until authorised by the Department. It is proposed that the Board shall consist of one member nominated by the Otago Institute, one member nominated by the Otago Acclimatisation Society, the Collector of Customs, the Chief Surveyor, and the District

Engineer of the Public Works Department. I am to ask you to be good enough to express your opinion on these proposals."

This suggestion did not quite meet the views of the contributing bodies, and further correspondence ensued. Indeed, the Acclimatisation Society took such an adverse view of the attitude of the Minister that, at a meeting held on the 25th April, 1902, it was decided "to withdraw the Society's offer of £250 towards the cost of the proposed hatchery." This difficulty was eventually got over, and the vote reinstated.

On the 24th April the Otago Institute nominated the author as its representative on the proposed Board; on the 22nd May the Acclimatisation Society nominated Mr. Robert Chisholm; and on the 9th June the Board was gazetted, its members being: Mr. David Barron, Chief Surveyor; Mr. Charles W. S. Chamberlain, Collector of Customs; Mr. Robert Chisholm; Mr. Charles E. W. Fleming, Superintendent of Mercantile Marine; and Mr. George M. Thomson.

The first meeting of the Board was held on the 24th June, when Mr. George M. Thomson was appointed chairman, Mr. Chamberlain undertaking to act as honorary secretary and treasurer. The Board got to business at once, and proceeded to make arrangements for the works required, calling in the assistance of Mr. J. Blair Mason, C.E., as consulting and supervising engineer. The necessary excavations and filling-in for tanks, ponds, &c., was executed by Mr. George Morrison, contractor, Dunedin, and the erection of the caretaker's residence and hatchery building by Messrs. R. Bauchop and Co., of Port Chalmers. Progress was very slow for a long time, as all plans, tenders, &c., had to be submitted to Wellington before they could be undertaken, and it was not till the beginning of July, 1903, that matters were sufficiently well advanced to necessitate the appointment of a clerk of works to supervise the construction. Out of nineteen applicants for the position, Mr. T. Anderton was selected.

By the beginning of 1904 the work was so much advanced, though far from being ready to commence operations, that the opportunity of the visit of the Australasian Association for the Advancement of Science to Dunedin was taken to formally open the hatchery. A large party of the members visited the site on the 13th January, and the station was formally opened by Professor T. W. Edgeworth David, F.R.S., President of the Association. At the meeting of the general council of the Association held on the previous day, a committee, consisting of Messrs. C. W. Chamberlain, D. Barron, and G. M. Thomson, was appointed "to investigate the local conditions affecting the food-supply of food fishes of New Zealand seas at the fish-hatchery at Portobello." Mr. Thomson was appointed secretary and convener, and a grant of £30 was placed at their disposal. This amount was supplemented later by the sum of £10—portion of an unexpended vote for marine biological research granted at the Hobart meeting.

At a meeting of the Board held on the 8th February, 1904, Mr. T. Anderton was appointed curator of the station, and the Board has had every reason since to congratulate itself on the appointment. The maintenance grant of £250 a year from the Government came into effect on the 1st April of the same year.

The total cost of the excavations, buildings, and fittings up to November, 1904, was £1,448. Towards this total the Government contributed £850, having voted £250 as a special grant over and above the £600 formerly promised; the two local societies each contributed £250; and calls were made on nearly all the acclimatisation societies of the colony for assistance. The following alone responded: Waitaki and Waimate Acclimatisation Society, £50; and the Hawke's Bay Acclimatisation Society, £25. The Canterbury Society expressed its readiness to assist with a donation as soon as the Board undertook the introduction of food fishes; and the Ashburton Society has also promised to give a sum *pro rata* as the other societies in Canterbury give. Financial assistance may be expected from several of the other societies when once the objects of the station are more fully understood, and the importance of the work undertaken is better appreciated.

The only remaining point to note in connection with the history of this movement is that Captain Fleming resigned his position on the Board in July, 1905, on his removal to Auckland, and that Captain Norman Beaumont, who succeeded him as Superintendent of Mercantile Marine, was appointed to the vacant position on the Board.

II. Descriptive.

The site selected for the fish-hatchery is at the north-west extremity of Quarry Point, the peninsula which projects halfway across Otago Harbour from Portobello. At no very remote date the upper and lower harbours were probably entirely separated from one another by an elevated rocky barrier, through which subsequently three channels have been formed, leaving Quarantine Island and Goat Island as the connecting-links which unite the Portobello side with Port Chalmers. A glance at the sketch-map (Plate LVII) shows the relative position of the headlands, islands, and dividing channels.

While the whole area of the harbour is probably undergoing silting-up, in large part due to the elevation of the east coast of

Otago, which appears to be still in progress, there is still a great extent of surface in the upper harbour over which the ebb and flow of the tide act. An immense body of water is thus continually passing to and fro through the three channels which separate the two main basins, and the scour keeps these channels relatively deep. The conformation of the land also causes the prevalent winds to blow with considerable force through these gaps in the dividing barrier, and when a strong south-west wind is blowing it drives through with immense force.

The position of the hatchery is just at the most easterly of these channels. The site covers 2½ acres, but the coast-line is of considerable length, owing to its deep indentations. The bays on the north-west and north sides are extremely well sheltered from the prevailing south-west winds by the high ground out of which they are hollowed, and two of these bays have been enclosed as retaining-ponds, and for the main hatchery buildings.

The depth of water immediately outside the main embankment at low water is about 18 in., and at high water from 6 ft. 6 in. at ordinary to 8 ft. 6 in. at high spring tides. The bottom is soft mud and sand, and deepens very slowly for a distance of about 500 ft., where from 12 ft. to 20 ft. is obtained in the channel between the hatchery and the sandbank, which extends practically to the Maori *kaik*, a distance of about four miles. This bank causes the flood tide for about the first two hours to flow from the main channel at Quarantine Island in a north-easterly direction towards Otago Heads. To the west of the hatchery the water in the channel is much deeper, and a great body of water is continually passing up and down at every tide, with a flow like a wide river.

Operations were commenced in July, 1903, for the construction of the hatchery, by enclosing a large bay on the northern side of the site, having a width of about 100 ft. and a length of 80 ft. An embankment, 14 ft. in width on the top, and pitched on the outside with large rough stones, was thrown across the entrance; and a similar embankment or platform, 30 ft. in width, was formed within this enclosure, just under the high ground to the west, for the erection of the hatchery buildings, engine-house, &c. A concrete wall, 10 ft. high, 2 ft. 6 in. at the base and 1 ft. thick at the top, was then built on the inside of the embankment, and a similar wall built across the middle, dividing the enclosure into two ponds of the following dimensions: length, 65 ft.; width, 30 ft.; depth, 4 ft. 6 in. to 7 ft.; and capacity, 60,000 gallons. These are controlled by means of screw-valves fitted into 9 in. earthenware pipes connecting with the outside water. The embankment has since been planted with suitable native shrubs and sown in grass.

The third pond has been constructed by enclosing and deepening a small rocky cleft on the north-west corner. The dimensions of this pond are—length, 50 ft.; width, 26 ft.; depth, 7 ft.; and capacity, 50,000 gallons. This pond has a rough rocky bottom and sides, with large crevices and overhanging rocky shelves, and should prove very suitable for its intended purpose —for the introduction of lobsters and crabs.

The supply-tank for the hatchery has been built in the solid rock immediately behind and about 20 ft. above the level of the embankment. The walls of this tank are of concrete, 1 ft. thick. The dimensions are—length, 33 ft.; width, 11 ft.; depth, 8 ft.; and capacity, 17,000 gallons. The tank is covered with a corrugated-iron roof. The water is led from this tank to the observation-tanks and hatching-boxes by 2 in. black-iron pipes, fitted with $\frac{3}{8}$ in. gun-metal cocks where required. The hatching-house, tank-room, and laboratory are all under one roof, the building being 49 ft. long by 21 ft. wide.

The hatching-house, 25 ft. by 21 ft., is fitted with two sets of Macdonald Patent Tidal hatching-boxes, six boxes to each set, and capable of dealing with from two to three million marine fish-eggs at one time. Provision in the way of tables and cocks is also made for using the Macdonald hatching-jars, of which the station has a good supply. The tank-room is 21 ft. by 10 ft., and in this have been built two glass observation-tanks, one 5 ft. by 5 ft., and the other 5 ft. by 2 ft. 6 in. The bottoms and stands have been built of concrete; the legs are 6 in. by 8 in., and the table of concrete is 4 in. in thickness. The glass is $\frac{5}{8}$ in. thick, and is fitted into a frame of $2\frac{1}{2}$ in. angle-iron, which which is let into a groove in the concrete table. Brass overflows are fitted, which are adjustable to any height by means of a rubber stuffing-box. In addition to the four windows it has been found necessary to fit four skylights in the roof of this room, and it is intended to do the same to the hatching-room. The floor of both these rooms is made of asphalt.

The laboratory is 21 ft. by 10 ft., and is well lighted by three windows facing the north, along which side a wide working-bench runs the full length of the room. A supply of fresh watei is also laid on to this room. The room is fitted with Leitz compound and simple microscopes, preserving, dissecting, and mounting apparatus, a large stock of glassware, and a small library. This latter includes sets of the "Transactions of the New Zealand Institute," of the United States American Fish Commissioner's Reports, and of the Scotch Fishery Board Reports, all presented to the station, and a number of other works dealing with biological and especially piscicultural subjects.

The roof of the whole building is of white-pine, covered with ruberoid.

The engine and pump house, situated on the same embankment, is built of corrugated iron. The pump, a 4 in. centrifugal, is driven by a $2\frac{1}{2}$-brake-horse-power Hornsby-Ackroyd oil-engine, and is capable of throwing 8,000 gallons of water per hour into the supply-tank, and also, by means of 4 in. earthenware pipes and wooden chutes, into any of the three ponds.

A four-roomed cottage with outhouses, placed on the top of the promontory point, and surrounded with a stake fence, completes the buildings of the station. Provision is made whereby any resident biologist, research student, or interested visitor can obtain board and lodging at a moderate rate. Application for this privilege has to be made to the Board.

A rain-gauge, supplied by the Meteorological Department, is placed in a suitable locality near the cottage, and daily readings are taken at the same time as the temperature records are made.

III. Scientific.

The scientific work done at a station like that at Portobello can only be of a very modest character as long as it depends entirely upon voluntary effort. Research on the development of almost any form of the local fauna requires much time as well as the requisite skill and knowledge. As an adjunct to the local University the station may ultimately prove of considerable advantage to the biological department, but until research scholarships are instituted this opening is not likely to be made much use of.

From the date of his appointment as curator, Mr. T. Anderton has made observations on the fauna of the neighbouring sea, and on the spawning of certain fishes. He has also recorded the hatching-out of these forms, and reared them for a longer or shorter time, preserving specimens at various stages, and making drawings of many of them. The same has been done with regard to certain species of *Crustacea.* These records are given under the different species referred to later on. He has also kept records of the temperature of the air, the water of the ponds, and of the bay outside the hatchery since the 1st January of this year. Since the 1st March of the present year he has kept a register of the rainfall, the Meteorological Office in Wellington having forwarded a rain-gauge to the station. These returns are appended to this report. Working as he does at present, single-handed, the curator has been quite unable to overtake the question of the salinity of the water—a thing which it is very desirable to ascertain.

In connection with the rearing of fry, and keeping any forms of life in confinement in tanks and jars, the usual difficulty was met with where the water-supply was stored in a concrete tank. It was fully a year from the completion of its construction before the water of the storage-tank was sufficiently free from lime-salts to be of any use. Very few organisms could live in it. This necessitated constant renewal of the various receptacles by fresh sea-water carried in from the bay. Such limitations hampered all the work of the kind undertaken, and indeed made continuous experiments almost impossible. These difficulties have now been overcome, and hatching during this last spring was done in the ordinary boxes with the overhead tank-water.

The Board recognises the desirability of having a complete list of the local marine fauna made out, and of having the life-histories worked out of those forms which have an important bearing on the rearing and feeding of fishes. But this is a work of time. In this report an approximately accurate catalogue of the fishes met with in Otago Harbour is given. But whole groups of organisms, some of them of great biological and economic importance, have never been looked into yet, and it will probably be long before systematic work is done upon them.

The station is fitted for research by any one competent and desirous to undertake it. The Board provides free accommodation for two such research naturalists, and board at a small cost can be arranged for. The only one who has so far taken advantage of this opportunity is Professor Chilton, D.Sc., of Canterbury College, who spent some time at the station last summer. The following papers, published in vol. xxxvii of the "Transactions of the New Zealand Institute," were the outcome of this visit: "Note on the Function of the Last Pair of Thoracic Legs in the Whale-feed (*Grimothea gregaria*)," and "On the Occurrence of a Species of *Cercaria* in the Cockle."

The author has worked with Mr. Anderton, the curator, and is responsible with him for the following notes and records.

The Flounder.

Two species of flounder are commonly obtained together in the harbour and along the coast, *Rhombosolea plebeia*, Richardson, and *R. tapirina*, Gunther, the latter being somewhat easily distinguished by the elongated snout-like upper lip.

On the 24th July, 1904, Mr. Anderton was out on the steam-trawler "Express," and noted that all the flounders taken were males, and that they were ripe, the milt flowing readily when the fish were gently pressed. No female fish were taken in the trawl-nets on that occasion. He also noted at the same time that no mature fish were obtainable in the harbour.

On the 19th May, 1905, a stock of flounders was obtained in the harbour by seine-netting on the edge of the banks at low water, and these were transferred to one of the ponds. These shallow-water fish were from $8\frac{1}{2}$ in. to 12 in. in length, and were not in a sexually far-advanced condition; there were about three male to each female fish. It was noticed that they lay about the deep end of the pond half buried in the mud, but on the beginning of the flood tide they always commenced to be more active. Towards evening also they moved about more freely, and food thrown into the pond and neglected during the day was always gone by the morning.

On the 5th June the temperature of the water in the ponds fell to 0° C., but the cold did not seem to trouble the fish. On the 7th June, with the temperature of the water at 1·2°, they were feeding quite freely.

On the 26th June 104 fish were in the ponds, all taken in rather shallow water; they averaged about 9 in. to 10 in. in length, and the females—even a few 12 in. or 13 in. fish—were not nearly ripe. On the same day, while netting in from 10 to 15 fathoms in the channel between Quarantine and Goat Islands, four large females were taken, and were found to be nearly ripe.

On the 20th July two 9 in. mature males and a 9 in. mature female were placed in the observation-tank, the latter fish being the only small mature female of its size noticed. They were kept in confinement for forty-two days, being returned to the pond again on the 31st August. During all that time the female fish ate no food at all, while the males ate voraciously every day. No ova were obtained.

The surface of the pond was tow-netted every morning, but no ova were obtained till the 3rd October, when about a thousand were secured. More were obtained pretty well every day till the end of the month, the total number secured being about 180,000.

Both species of *Rhombosolea* being together in the ponds, it was not possible to distinguish the two kinds of ova. In one case the egg averages 0·82 mm. in diameter, and has only one relatively large oil-globule. The egg of the other species is distinctly smaller, averaging 0·65 mm. in diameter, and is furnished with from eight to thirteen small oil-globules. The two kinds are quite readily distinguished from one another, but unfortunately it was impossible to separate the eggs, or to determine the species to which they belonged. This can be done again when the stocks of flounders kept in the ponds are strictly separated. In connection with the occurrence of the oil-globules in these eggs, attention may be drawn to a hypothesis advanced by Dr. J. T. Cunningham in the "Journal of the British Marine Biological Association" (vol. i, p. 48), in which he seeks to trace a connection between the occurrence of oil-globules in the yolk of the egg and the presence of much or little oily matter in the tissues of the parent fishes. This point also can be looked into when the species have been worked out separately.

In about four days after the ova were obtained and fertilised the larvæ began to hatch out, and they were kept in the boxes for about fourteen days and then liberated. Specimens of these larvæ were preserved and mounted every day, and drawings were made by Mr. Anderton, but until the identity of the species is established it is thought undesirable to reproduce these, or to publish any notes on them.

We have reason to believe that the fish in the ponds either cannot get rid of their ova without difficulty, or do not do so for some unexplained reason, in the shallow water. Some two hundred fish in all were kept in the pond, of which over one-fourth were mature females, yet only a very few appear to have liberated their eggs. The mature fish taken in June of this year were obtained only in deep water, while last year no females were got at all in the trawl-nets on the trip of the 24th July. It seems as if the fish moved out into deep water at spawning-time, but whether this is connected with the more effective distribution of the species, or whether the greater pressure of the water in any way facilitates the extrusion of the ova, is problematical. It may be only a question of temperature; while the pond water frequently cooled down sometimes as low as 5° C., that of the ocean at the same time probably never fell below 10°.

Another piece of knowledge gained is the hardiness of both species of *Rhombosolea*. They seemed to be unaffected by the low temperatures which prevailed in the ponds during the winter months, except perhaps in the retardation of their sexual maturity.

During October it was noticed that several of the fish in the ponds were showing sores. These were found on both the upper and under sides, but appeared most commonly on or near the base of the pectoral fins, and seemed to pass into ulcers which ate down to the bone, in some cases proving fatal to the fish. They were not confined to the fish in the pond, though rather frequent among them, but were found in the fish taken in the bay with seine nets. The cause is obscure, but the mature females with distended ovaries which had not discharged their eggs appeared to suffer most from the trouble. The tissue removed from the ulcers showed under the microscope at least two forms of ciliated infusorians, but whether these were the cause or only an accompanying result of the disease is not known. It is interesting to record that Mr. Anderton took out some of the diseased fish, and touched the sores with weak solution of corrosive sublimate before returning them to the pond. The cautery seemed to be effective, and the sores healed in several cases. Probably a second application would have completed the cure in all.

In November most of the fish were allowed to escape into the bay, as it is always possible to obtain abundance of both species just before spawning-time.

The Brill (Caulopsetta scapha).

The fish known by this name is occasionally taken by the trawlers outside Otago Heads. Its erratic occurrence, like that of many other species, is probably due to the alterations in the temperature of the water along the coast; but until these have been carefully studied it is impossible to do more than surmise this to be the case. On the 24th July, 1904, Mr. Anderton obtained ova from large female fish taken on the trawler; unfortunately no male fish were taken, so that the eggs could not be fertilised.

The Lemon Sole (Ammotretis rostratus).

This fish is popularly known as the lemon sole, to distinguish it from *Peltorhamphus novæ-zealandiæ*, Gunther, which the local fishermen call the English sole. The names are somewhat unfortunate, seeing that they are applied to totally different species in Britain.

Some experimental work was carried out with regard to *Ammotretis* during the past two seasons. In July and August of last year Mr. Anderton was out in the trawler on several occasions, and obtained a stock of fish for the ponds. These were kept in confinement till the end of October, but it was soon found that all were more or less bruised by the crushing to which they had been subjected in the trawl-net, and they never recovered from this. Numbers died, and all got into poor condition and became affected with sores on various parts of the body. It was noted at the same time, however, that fish taken in the bay in the seine nets were also more or less similarly affected.

No ova were obtained, though usually the fish seemed to liberate their eggs in August, and ultimately the remainder of the stock in the ponds were turned out again into the bay. Just as in the case of the flounders, it seemed as if the fish were unable to extrude their ova in the shallow water of the ponds, or else that the low temperature of the pond-water affected them adversely.

On the 17th August of this year Mr. Anderton was out again in the trawler, and obtained several thousand ova. Many female fish taken were found to be spent, and ripe males were abundant. On this date, while the water at the hatching-ponds was at 5° C., that of the open sea at 18 fathoms depth was 10° C. More ova were obtained on the 20th August, and altogether about 250,000 eggs were got.

The egg of this species is about 0·8 mm. in diameter (Plate LV, figs. *a–f*), and contains from eight to eleven oil-globules. The minute structure was not studied.

About the fourth day after fertilisation the black pigment spots began to show, and by the following day the outline of the embryo was distinctly visible. On the seventh day the black and yellow spots of the young embryo were uniformly distributed, and the larvæ began to hatch out on the ninth day. The temperature all this time remained low, varying from 2·8° to 4·8° C. These larvæ were reared till their tenth day, by which time the yolk-sac was nearly absorbed, and they were then turned out into the harbour. Altogether about 168,000 were liberated. These results are very small and fragmentary, but it has to be borne in mind that they were achieved by one worker, who was daily occupied with all the ordinary routine duties of the station, and who had had no previous experience of the work.

Blue-cod (Parapercis colias, *Forster*).

Eggs of this species were obtained from some fish in the ponds about the end of October and beginning of November, 1904. The egg is a floating one, having a diameter of 1·05 mm.

The eggs hatched out in about three days, and the larvæ were reared till about a week old, by which time the yolk-sac was almost completely absorbed, and the fry were swimming about freely and feeding. At that time the store-tank water was unusable on account of the lime present in it, and thus it was extremely difficult to keep experimental jars and small tanks going, hence no further attempt was made to study the development of these few larvæ. The approximate date of spawning and the length of time taken to hatch out being ascertained, it was realised that the experiment could be resumed with more prospect of success on a future occasion.

A very interesting experiment was made in connection with these fish. About three dozen were obtained on the 11th October last year, in about 30 fathoms of water off Cape Saunders, and were transferred to one of the ponds. A dead specimen examined at the same time was found to have the stomach quite full of seaweed. But in the pond they were regularly fed on cut-up fish, cockles, &c., and they fed freely, becoming so tame that they came about the edge of the pond whenever visitors went to see them, and they would take food out of the hand, and allow themselves to be stroked. About a month after they were confined some of them became affected by a whitish film which grew over one or both eyes, and it looked as if they would become blind. But by the end of summer this had quite disappeared, and the fish were in very fine plump condition. A few of them also showed greyish patches, apparently of diseased tissue, on the back, but this condition did not affect many, and was not closely examined into.

During May of this year, when the weather was rather cold, the fish almost ceased to feed, and did not move about freely. Even cockles, of which they were extremely fond, had no temptations for them. On the 2nd June there was a little snow at intervals, and the pond-water was very much chilled. On the 3rd there were snow-showers during the day, and the pond-temperature registered 1·4° C. Heavy snow came on during the night, and on the morning of the 4th it lay 3 in. or 4 in. deep on the ground, while the temperature of the pond went down to 0·8° C. One of the cod was found dead, and five or six more were lying on their sides in a nearly dead condition. During the night the temperature fell still lower, that of the pond standing at 0° C., and on the morning of the 5th the rest of the fish were lying on their sides, all dead but five. An attempt was made to resuscitate these by keeping them in somewhat warmer water, but they all succumbed on the 6th.

It is worthy of note that while blue-cod are obtainable in Otago Harbour during the summer months, they appear to migrate out to deeper water on the approach of winter, and, further, that they do not take bait during cold weather.

This experience is of value as showing, among other things, the limitations to which experimental work is liable in shallow-water ponds.

Congiopodus leucopœcilus, *Richardson.*

This fish is popularly known as "pig-fish," on account of the grunting noise it makes when taken out of the water and left to gasp for air. It is sometimes called "leather-jacket," a name which, however, is more correctly applied to *Monacanthus scaber*, another very common fish in Otago Harbour.

On the 17th September of last year Mr. Anderton secured male and female mature specimens, and from these he obtained eggs which he artificially fertilised. Being at the time extremely busy with other and more important work, he kept neither record nor drawings of these eggs. On the 16th October, the temperature of the water in the hatching-house being 6° C., some of the eggs were ready for hatching out, the larvæ showing in a well-developed condition, the eyes and pectoral fins being especially prominent (Plate LVI, fig. *d*). The specimen figured was just about to hatch, and the larvæ when liberated floated with the yolk-sac uppermost. By the sixth day the yolk-sac was nearly absorbed (fig. *e*), and the little fish were swimming about freely, with much of the slow motion characteristic of the adult. The development could not be followed further on account of the numbers of other fry to be attended to.

Crustacea.

Some experiments were made in regard to common forms of *Crustacea*, which may be placed on record here, though the results have not been worked out yet.

Heterograpsus sexdentatus, Milne-Edwards, is one of the commonest of shore-crabs, and is found under stones between tide-marks. A berried female kept in an aquarium jar spawned on the 28th August, 1904. The zoeæ swarmed in the water, and the parent crab immediately commenced to eat them up wholesale. The development was not followed out.

Petrolisthes elongatus, Milne-Edwards, is another extremely common form in similar localities. Berried females in an aquarium jar spawned from the 17th to the 23rd November. The zoeæ were watched from day to day, and a fairly complete series was obtained and preserved. There has not been time to work out the results as yet. The water of the bay was full of zoeæ for some weeks.

Palæmon affinis, A. Milne-Edwards: This is the common small prawn of the harbour. A single berried female liberated its ova—about three hundred—on the 15th January of this year. The larvæ were very active, darting about in all parts of the jar, but invariably seeking towards the light side. Their cannibal propensity was very marked from the first, a feature apparently of all larval *Crustacea*, as well as of a good many adult forms. If not liberally supplied with minced cockle, which they ate greedily, they at once attacked each other. The development was watched from the 15th January to the 22nd April, a period of ninety-seven days, during which they underwent eleven moults. The dates of these moults were as follows: First moult, 20th January; second moult, 26th January; third moult, 2nd February; fourth moult, 6th February; fifth moult, 11th February; sixth moult, 15th February;

seven moult, 21st February; eighth moult, 26th February; ninth moult, 5th March; tenth moult, 19th March; eleventh moult, 8th April. The adult form appeared to be reached at the tenth moult, the motion in swimming and the general appearance being different from what it was in the earlier stages. Fairly complete sets of these various stages have been preserved, and it is hoped to work them out during the coming year.

Munida subrugosa, Miers: An attempt was made to prove the identity of this species with *Grimothea gregaria*, the free-swimming form known as "whale-feed," which is so abundant in our seas, especially in the summer months. Owing to the nature of the tank-water and pressure of other work the experiment failed. While there seems little doubt as to the identity of these two forms, yet until *Grimothea* has been reared from the eggs of *Munida* the fact cannot be considered proved. This is the principal food material of a great many species of fish during a considerable part of the year, and the knowledge of its life-history is important and desirable.

Scientific Notes by Mr. Anderton.

The following notes made at various times by the curator are well worthy of being placed on record:—

(1.) I have never read of the yawning of fishes, but I have repeatedly seen blue-cod, flounders, and soles in the ponds having a decided yawn. The mouth is opened to its full extent, as also are the gill-covers. This is continued for a few seconds, when the mouth is shut with a snap. I have observed the same thing in the glass tanks in the case of spotties (*Pseudolabrus bothryocosmus*) and flounders. The phenomenon has been chiefly observed when the ponds were low, but the reason of this is not known. It may be that it was only that the fish were more easily observed.

(2.) The following fact is worth recording. On the 12th–13th October 1·4 in. of rain fell, and on the latter date 25,000 ova were collected from the surface of the pond. This is one of the heaviest rainfalls recorded, but it did not interfere with the collection of the ova, nor apparently with their condition after collection.

(3.) During the winter months there appears to be a general exodus of fish from the harbour. I think this is most noticeable in the case of the flounders. Perhaps the difference in temperature between the water of the bay and of the open sea, together with the supposition that they seek deeper water on account of the increased pressure to assist the extrusion of the eggs, may account to a great extent for this annual migration. The following table gives an approximate idea of the difference of temperature referred to. The ocean record was made by the engineer of the steam-trawler "Express" during two months of this year :—

TEMPERATURES OF SURFACE WATERS OF BAY AND OCEAN SIX MILES OFF OTAGO HEADS.

Date.	Bay.	Ocean.	Date.	Bay.	Ocean.	Date.	Bay.	Ocean.
	°C.	°C.		°C.	°C.		°C.	°C.
July 20	2·4	9·0	Aug. 11	2·8	10·0	Aug. 28	3·8	11·0
,, 23	3·2	10·0	,, 14	3·4	8·4	,, 31	4·8	9·6
,, 24	3·4	8·5	,, 15	3·8	9·5	Sept. 1	5·8	9·6
,, 25	3·2	8·8	,, 17	5·2	9·5	,, 6	5·6	9·6
,, 26	3·4	8·8	,, 20	3·6	9·5	,, 7	5·4	9·2
,, 27	3·2	9·2	,, 21	3·8	11·0	,, 11	5·8	12·0 (?)
Aug. 8	4·4	9·8	,, 22	4·4	9·8	,, 12	6·2	9·8
,, 9	4·2	9·8	,, 24	3·2	9·4	,, 13	5·8	7·0 (?)
,, 10	2·8	9·0	,, 27	4·0	10·2	,, 15	5·4	9·0

(4.) *The Dog-fish.*—The idea that these fish are the natural enemies of most of our edible fishes, excluding flat-fish, is generally accepted by the fishermen. Although, from the small numbers of these examined, and the short period of time during which the observations were made, I would not like to affirm absolutely that this is not so, I think it is worth recording that from January to May, 1905, I examined the contents of the stomachs of between fifty and sixty spinous dog-fish (*Cephaloscyllium laticeps*) and smooth-hound (*Galeus antarcticus*). Only one of these contained fish, and that appeared to be a piece of king-fish that had been cut with a knife. Their stomachs generally contained large crabs (*Cancer novæ-zealandiæ*) and other unrecognisable species, *Grimothea gregaria, Munida subrugosa*, and worms.

(5.) During such times as they are found in the bay *Grimothea gregaria* have been found in the stomachs of almost all the fish examined, including sea-trout, spotties, pig-fish, dog-fish, rock-cod, red-cod, blue-cod, barracouta, and Maori chief.

(6.) It is hoped that in future a closer observation of the tides may be made. The effects of the moon's north and south declination in apogee–perigee, of the effects of winds, high and low local barometer, &c.—all these need recording. The station is admirably situated for such study, which, carried on carefully through a number of years, would no doubt be of considerable scientific value.

(7.) *Ocean Currents.*—So far it has not been possible to make any observations of these currents. The Admiralty chart shows a current off Cape Saunders setting in a northerly direction at a rate of from one to one and a half knots an hour. The captains of the trawlers and the line-fishermen affirm the accuracy of this statement, the latter stating that at times it is so strong as to prevent them from fishing, as they are unable to get their lines to the bottom. These currents must have considerable influence on the migration and food-supply of our sea-fishes, and in order to acquire a fuller knowledge of their spawning habits and grounds it is necessary to take this into consideration. For instance, identified pelagic fish-eggs of a known age—say, fifth day—taken in the tow-net off Otago Heads, with a current of two knots an hour setting to the northward, would have been shed about two hundred and forty miles south of the place at which they were taken.

List of Fishes which have been taken in Otago Harbour or in the Immediate Proximity.

1. *Polyprion prognathus*, Forster. The groper occurs outside the Heads all the year round, and occasionally comes into the harbour, keeping to the deeper parts.
2. *Arripis trutta*, Cuvier. The kahawai is an occasional summer visitor.
3. *Pagrosomus auratus*, Forster. The snapper is another occasional visitor, and also appears to come only in the summer months.
4. *Haplodactylus meandratus*, Solander. The granite trout is not infrequently met with in the harbour.
5. *Chilodactylus macropterus*, Forster. Recorded in Trans. N.Z. Inst., vol. xi, p. 381.
6. *Latris ciliaris*, Forster. The moki occurs all the year round, and is a common fish near the rocks, and especially among kelp.
7. *Latris lineata*, Forster. The trumpeter is not so common as it used to be. It is still met with at intervals, but used to occur in all the deeper channels, near rocks.
8. *Latris ærosa*, Hutton. The type of the species was taken at Otago Heads, and is in the Otago Museum.
9. *Congiopodus leucopœcilus*, Richardson. One of the commonest fishes in Otago Harbour, where it is known as "pig-fish," or sometimes as "leather-jacket."
10. *Neophrynichthys latus*, Hutton. Sometimes called "toad-fish."
11. *Genyagnus maculatus*, Forster. The cat-fish or hard-head

12. *Kathesostoma fluviatilis*, Hutton. Trans. N.Z. Inst., vol. xxviii, p. 315.
13. *Notothenia maoriensis*, Haast. Commonly known as "Maori chief."
14. *Notothenia angustata*, Hutton. The type is in the Otago Museum.
15. *Notothenia cornucola*, Richardson. Trans. N.Z. Inst., vol. v, p. 262.
16. *Notothenia microlepidota*, Hutton. Not uncommon outside the Heads, and sold as "black-cod."
17. *Parapercis colias*, Forster. The blue-cod is common outside the Heads, in deep water near rocks.
18. *Trachyichthys trailii*, Hutton. Dunedin Harbour. Trans. N.Z. Inst., vol. xvii, p. 162.
19. *Lepidopus caudatus*, Euphrasen. The frost-fish frequently comes into the harbour in winter-time, and gets stranded on the beaches and sandbanks.
20. *Thyrsites atun*, Euphrasen. The barracouta is an erratic visitor, sometimes occurring in immense numbers. The young are abundant in the harbour in the summer months.
21. *Promethichthys prometheus*, Webb and Berthel. The kingfish is met with not infrequently in the harbour, and is got occasionally in considerable quantity in the trawlers.
22. *Caranx georgianus*, Cuvier. The trevalli is a common fish in the harbour.
23. *Trachurus trachurus*, Linnæus. The horse-mackerel or scad.
24. *Seriola lalandii*, Cuvier. This fish, the "king-fish" of the North Island, appears to be an occasional visitor to these waters.
25. *Evistius huttoni*, Gunther. Dunedin. Trans. N.Z. Inst., vol. ix, p. 470.
26. *Seriolella porosa*, Guichen.
27. *Seriolella brama*, Gunther. (?) Warehou.
28. *Cyttus novæ-zealandiæ*, Arthur. Taken off Otago Heads. Trans. N.Z. Inst., vol. xvii, p. 163.
29. *Trigla kumu*, Lesson. The gurnard is occasionally taken inside the Heads, and is also brought in by the trawlers from outside.
30. *Tripterygion tripinne*, Forster. Popularly known as the "cock-a-bulli" (perhaps a corruption of "kokopu"); abundant near the beach.

31. *Agonostomus forsteri*, Bloch. The sea-mullet or herring is one of the commonest fishes in the harbour, and occurs all the year round.
32. *Diplocrepis puniceus*, Richardson. The sucker; common in rock-pools.
33. *Lophotes fiskei*, Gunther. Taken at St. Clair. Trans. N.Z. Inst., vol. xxvi, p. 223.
34. *Regalecus argenteus*, Parker. Great ribbon-fish; caught near Portobello. Trans. N.Z. Inst., vol. xx, p. 20.
35. *Regalecus parkeri*, Benham. Taken at Deborah Bay. Trans. N.Z. Inst., vol. xxxvi, p. 198.
36. *Odax vittatus*, Solander. Kelp-fish. Otago Heads and inside the harbour occasionally.
37. *Pseudolabrus bothryocosmus*, Richardson. Locally known as "butter-fish" or "spotty"; very common.
38. *Pseudolabrus cinctus*, Hutton. Not uncommon on the coast. The type is in the Otago Museum.
39. *Caulopsetta scapha*, Forster. Known as the "brill"; occasionally got in the trawl-nets.
40. *Ammotretis rostratus*, Gunther. Locally known as the "lemon sole."
41. *Rhombosolea plebeia*, Richardson. Common flounder.
42. *Rhombosolea flesoides*, Gunther. Yellow-belly; not so common as the last.
43. *Rhombosolea tapirina*, Gunther. Common.
44. *Peltorhamphus novæ-zealandiæ*, Gunther. The common sole.
45. *Physiculus bacchus*, Forster. The red-cod is one of the most abundant fishes on the coast.
46. *Pseudophycis breviusculus*, Richardson. Occasionally taken, and locally known as "whiting."
47. *Merluccius grayi*, Guichen. Locally known as "haddock."
48. *Genypterus blacodes*, Forster. The ling occurs all the year round outside the Otago Heads.
49. *Hemirhamphus intermedius*, Cuvier. The garfish; occurs at intervals in the harbour.
50. *Gonorhynchus greyi*, Richardson. The sand-eel; not uncommon.
51. *Clupea sagax*, Jenyns. The pilchard or sardine occurs in immense shoals, which appear to pass up the coast in a northerly direction during the summer months.
52. *Leptocephalus conger*, Willoughby. The conger-eel.
53. *Hippocampus abdominalis*, Lesson. The sea-horse is very abundant in the harbour.

54. *Stigmatophora longirostris*, Hutton. Trans. N.Z. Inst., vol. viii, p. 216.
55. *Ichthyocampus filum*, Gunther. The pipe-fish ; another very common fish in the harbour.
56. *Monacanthus scaber*, Forster. The leather-jacket ; common in the harbour.
57. *Mola mola*, Linnæus. An occasional sun-fish has been taken in the harbour.
58. *Callorhynchus antarcticus*, Lacepede. The elephant-fish ; a migratory species, occasionally occurring in large numbers.
59. *Dasybatis brevicaudatus*, Hutton. Stingaree ; not uncommon.
60. *Torpedo fusca*, Parker. The type of this species was got at Purakanui. Trans. N.Z. Inst., vol. xvi, p. 281.
61. *Astrape aysoni*, Hamilton. Another species of torpedo ray; occasionally met with near Dunedin.
62. *Raia nasuta*, Solander. The skate ; common.
63. *Galeus antarcticus*, Gunther. The smooth-hound ; occasionally taken in the harbour.
64. *Alopias vulpes*, Gmelin. The thresher ; an occasional visitor.
65. *Cephaloscyllium laticeps*, Dumeril. The dog-fish is very common.
66. *Echinorhinus spinosus*, Cuvier. The spinous shark has been taken off Otago Heads.
67. *Heteropleuron hectori*, Benham.

Introduction of Lobsters.

The desirability of introducing the European lobster (*Homarus vulgaris*) into these seas has been before the promoters of this station since its inception. It has been stated that there is no need to introduce this crustacean, seeing that the marine crayfish (*Palinurus*) is so common, and is such an excellent article of food. While these facts are quite admitted, yet it is the case that the lobster has a much greater commercial value than the crayfish, and if once acclimatised in these waters would prove a very valuable addition to the wealth of our fisheries. Again, it has been objected that the chances of establishing a species which undergoes various metamorphoses in its early stages, when it passes through several free-swimming stages, when it cannot well be handled, are very great. But the hatching and rearing of lobsters, both *H. vulgaris* and *H. americanus*, have been successfully accomplished at several stations in the Northern Hemisphere. Nowhere, indeed, has this work been more successfully carried out than at the biological station of the Commissioners of Inland Fisheries, Rhode Island, U.S.A.; and Dr. A. D. Mead, of Brown University, with his small floating laboratory, has been able there to rear vast numbers of these crustaceans to a stage when they ceased to swim, and could be liberated on a rocky bottom. All the available information on this subject has been kindly communicated to the local Board by Dr. Mead. It is also the case that the common shore crab of Britain (*Carcinus mœnas*) has been introduced into Australian waters within the last few years, and has spread round the shores of Port Philip. How it was brought out is not clear—perhaps in ballast, or attached in some way to ships' bottoms—but the occurrence is recorded by Mr. S. W. Fulton in the "Proceedings of the Royal Society of Victoria," vol. xiv, p. 55.

The possibility of conveying live lobsters to the colony was solved by the Otago Acclimatisation Society in 1891, when nine specimens were brought out by Mr. Purvis, chief engineer of the s.s. "Ionic." There being no suitable place in which to keep them, these specimens—which were in fine condition—were taken down to the mole at Otago Heads and liberated there. The locality is one exposed to all easterly weather, and is subject to continual strong tidal currents which carry shifting sands. It was therefore most unsuitable for lobsters, which, like other crustaceans, try to keep their gill-chambers as free as possible from sand. Nothing was ever heard of them again, and the experiment has not been repeated since.

During 1904 preparations were made at the hatchery for a lobster-pond, and a large natural cleft in the rocky promontory on which the hatchery is situated was deepened and cut off from the outer channel by a concrete wall and embankment, fitted with valve openings, &c. The pond is about 50 ft. long, 26 ft. broad, and can be filled by the pump to a depth of 9 ft., the ordinary depth at high water being from 6 ft. to 7 ft.

Advantage was taken of the visit of Mr. R. Chisholm, a member of the Board, to England during this last year to arrange for a trial shipment of lobsters. Communications were entered into with Dr. E. J. Allen, Director of the Marine Biological Association, Plymouth, who kindly undertook to procure the required crustaceans and forward them to London. The manager and other officials of the Shaw, Savill, and Albion Company also took up the scheme heartily, and commenced to make the necessary arrangements for the conveyance of the lobsters to New Zealand in one of their steamers leaving for Port Chalmers. When Mr. Chisholm left London everything seemed in train for the forwarding of the first trial lot. But it was found that the expense of fitting up the necessary tanks on board the steamer was going to run into a great deal more money than was originally contemplated, and, pending further instructions, those who had the matter in hand at Home suspended operations till they got the necessary authority. After Mr. Chisholm's return to the colony he stated fully what he had attempted and accomplished, and the Board at once wrote to London asking that the preparations for forwarding the lobsters be again proceeded with. It is therefore anticipated that a shipment will reach Port Chalmers ere long by one of the direct steamers.

Temperatures (in °C.) of Air, in Shade, of Bay and Ponds for 1905.

(Recorded at 9 a.m. daily.)

Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.
Jan.				Feb.				Mar.			
1	10	11·6	11·4	1	11	11·4	11	1	10·4	10·6	10·2
2	3·8	9·8	8·4	2	12·4	12·2	12·8	2	12·2	11·4	11
3	6·4	8·6	7·8	3	13·2	12·4	12·2	3	11·6	11·6	11·4
4	6·4	7·8	7·6	4	15·2	13·8	14	4	13·8	12·2	12·4
5	7·9	8·8	8	5	15·8	14·2	15	5	13·2	12·4	12
6	10·4	10·8	10·6	6	12·6	13	14·2	6	10	11·4	10·8
7	9·7	10·4	10·8	7	12·4	12·8	12	7	9	11	9·6
8	11·4	9·8	10·4	8	12·2	12·8	12	8	9	10·4	9·6
9	8·8	9·9	10	9	10·2	12·6	12·2	9	10·6	11·2	10·6
10	10·8	10·2	10·8	10	12·4	11	12·2	10	13·2	11·6	12
11	12·2	11·4	11	11	16	14·4	14·8	11	11·4	12·2	11·6
12	11·6	10·8	10	12	14·8	14·6	14	12	11·8	12·6	12·2
13	15	12	12·4	13	12·8	14	13·2	13	10·4	12·2	11·6
14	14	12·4	12	14	12·8	15·2	14·6	14	12·4	12·2	11·6
15	14	11·8	12	15	14	15·4	15·4	15	12·2	12·2	12
16	11	12·4	11·4	16	11·4	13·6	14·2	16	10·4	12	11·2
17	10·2	11·2	11	17	11	12·8	12	17	11	11·8	11·4
18	10·8	10·8	10	18	10·4	12·2	12	18	11·6	11·6	11·2
19	11	11·6	10·8	19	13	13·2	12·2	19	9·8	11·4	10·6
20	12·6	11·4	11	20	11·4	12·8	12·2	20	12·4	12	12
21	12·2	11·4	11·4	21	12·4	12·8	12·2	21	12	11·6	11·4
22	13·8	12·4	12	22	13	12·6	12·2	22	11·8	11·6	11·8
23	12·2	12	12	23	11·2	12·2	12	23	10·4	11·2	11·8
24	10·4	11·4	11	24	12 2	12·8	12·4	24	10·4	11·4	11
25	9	10·8	9·6	25	13	13·2	12·8	25	9·8	10·2	10
26	8·4	9·8	9	26	10	11·8	11	26	9·4	10	10
27	10	10·4	10	27	10	11	9·8	27	12·4	9·8	11
28	10·4	10·6	10	28	10·2	10·6	10·4	28	10·8	10·2	10
29	12·2	11	10·8					29	10·8	10	10
30	11·6	11·4	11					30	11·2	11·4	10·6
31	11·2	11·6	11·4					31	12	11·4	11·2

TEMPERATURES (IN °C). OF AIR, IN SHADE, OF BAY AND PONDS FOR 1905—*continued.*

Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.
Apr.				May.				July.			
1	12·2	11·8	12	17	6·8	6·2	6	1	2·8	3·4	3
2	12	11·4	11·2	18	5	5·8	5·6	2	4	3·2	3
3	7·8	9	8·6	19	3·6	6	4·8	3	0·2	2·4	1·2
4	7·8	9	8·4	20	5·8	5·6	5	4	0·4	2·2	1·4
5	9·2	9·4	8	21	4·6	5·2	5	5	3	2·2	1·8
6	6	8	6·4	22	2·8	5	4	6	2·4	2·8	2·6
7	9·4	8·2	8·6	23	2·2	5	4·2	7	2·8	2·6	2·4
8	7	8	7·6	24	4·4	5·2	4·6	8	2·2	3	2·6
9	7·8	8·2	7·8	25	6	4·8	3·8	9	0·4	3	2·6
10	8·2	8·4	8	26	1	4·8	2·4	10	2	2·8	2·6
11	9	8·6	8·6	27	3·2	4·4	3·4	11	2	2·2	2
12	9·4	9·2	9	28	2·8	4	3·6	12	5	2·8	2·2
13	9	9·2	9	29	4·6	4·4	4·2	13	4·2	3	3·2
14	6·6	8·4	7·4	30	2·8	4	3·8	14	3·8	3·2	3·4
15	6·8	8	7	31	5·4	4·8	5	15	3·2	3·4	2·8
16	9·8	8·8	8·6					16	1·4	3	2
17	8·2	8·6	8·6					17	1	2·8	1·4
18	8·2	8·4	8·6					18	0·6	2	1·4
19	8	8	7·6	June.				19	2·4	2	1·6
20	7	7·6	7·4	1	4·6	4·8	4	20	3	2·4	2
21	6·4	7·2	7	2	2·2	4	3·8	21	3·4	2·4	1·8
22	5	6·8	6	3	0·8	3	1·4	22	5	2·8	2·4
23	6·2	6·6	6	4	0·2	2	0·8	23	7·8	3·2	3·4
24	8·4	7	7	5	0·2	1·6	0	24	6·2	3·4	3·4
25	6·4	7	6·8	6	2·2	1·8	1	25	3	3·2	3
26	5	7·2	6·4	7	0·8	1·8	1·2	26	4·2	3·4	3·4
27	7	7·4	7	8	3·6	2	1·8	27	2·2	3·2	3
28	6·4	7·4	6·8	9	4·6	2·8	3·8	28	3·8	3·4	3
29	6·8	7·6	7·4	10	2	2·8	2·4	29	3·4	3·4	3·2
30	6	6·6	6·4	11	3·8	2·8	2	30	3·6	3·4	3·4
				12	3·2	3	2·2	31	3	3·4	3
				13	3·2	3·2	3				
May.				14	4	3·2	3·2	Aug.			
1	5·4	7	6·2	15	1·2	3·2	2·6	1	2·6	3·2	2·8
2	7·8	7	7·6	16	2	2·8	2·8	2	4	3	2·6
3	4·8	6	6·2	17	1	2·8	2·6	3	4·8	3·6	3·4
4	3·8	6·2	5·8	18	1	2·8	2·4	4	2·8	3·6	2·4
5	8·6	6·8	7	19	2	3	2·4	5	4	3·8	3·6
6	6·6	7·4	7	20	2	3·2	2·6	6	1·6	3·6	2·8
7	8·2	7·6	8	21	5	3·2	3·4	7	3·8	3·8	3·2
8	8·8	8	8	22	5·4	3·6	3·6	8	5·8	4·4	4
9	8·8	8·2	8·2	23	5·4	3·6	3·8	9	4·2	4·2	3·6
10	8·3	8·4	8·4	24	5·8	4·4	4·6	10	1	2·8	2
11	9·6	8·6	8	25	3·6	3·8	3·8	11	1·4	2·8	2·6
12	5·4	7·8	6·6	26	3·6	3·8	3·8	12	2·2	2·2	2
13	4·4	6·2	5·8	27	2	3	3·8	13	4·4	3·6	3·2
14	5·8	6·2	6	28	3	3·4	3	14	2	3·4	3·2
15	4·4	5·8	5	29	2·6	3·6	3·2	15	4·2	3·8	3·8
16	4·8	5·4	5	30	3	3·4	3	16	3	4·2	3·8

Temperatures (in °C.) of Air, in Shade, of Bay and Ponds for 1905—*continued.*

Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.	Date.	Air.	Bay.	Pond.
Aug.				Oct.				Nov.			
17	7	5·2	4·2	1	6	5·4	5·4	16	8·6	9·4	9
18	4	4·4	4·4	2	5·4	6	5·4	17	14·4	10·8	11
19	3·4	4·2	3·8	3	4	6·2	5·6	18	16·8	11	10·6
20	2·4	3·6	3·4	4	7·4	6·8	6·6	19	11·4	10·8	10·8
21	1·2	3·8	3	5	8·2	7·6	6·8	20	12·2	11	11·6
22	4	4·4	4·2	6	9	7·4	7	21	17·8	12·2	13
23	2·6	3·6	2·8	7	9	8·2	8·4	22	8·6	11·4	11
24	3	3·2	2·6	8	8·6	8·2	8	23	9·8	10	8
25	4·6	4·2	4·4	9	7	7·6	7·6	24	9	9·8	9·8
26	3	3·2	3	10	4·4	6·4	5·8	25	12·2	9·8	10·2
27	3·4	4	3	11	5·8	6·6	6	26	12·6	10	10·2
28	3	3·8	3·6	12	7	7	6·8	27	11·6	10	10·2
29	4	3·6	3·6	13	5	7	6	28	11·8	10·2	10
30	3·8	4	3·8	14	4·2	6·4	5	29	11·4	10	10
31	5	4·8	4·2	15	7·8	7	6·8	30	6·6	11	9·8
				16	6·8	6·8	6·6				
				17	7·6	7·6	7·8	Dec.			
Sept.				18	6·4	7·8	7·8	1	10·2	11	9·6
1	6	5·8	4·8	19	7	7·8	7·6	2	12·2	10·2	11
2	5·8	5·4	5	20	7	7·6	7·6	3	9·8	9·6	Open
3	6	5·4	5·2	21	9·2	8	8·2	4	12·8	10·6	,,
4	5·8	5·4	5·2	22	8·6	8·2	8	5	12·2	11	,,
5	5·8	5·8	5·6	23	6·8	8·6	8·8	6	10·6	11·4	,,
6	4·4	5·6	5·2	24	4·6	8·4	7·8	7	12·4	12	,,
7	3·4	5·4	5·6	25	4·8	7·6	6·8	8	12·2	12	,,
8	4·2	5·4	5	26	5	7	7	9	10·2	11·6	,,
9	5	5	4·6	27	7	7·4	7	10	12	12	,,
10	5·2	5	4·8	28	7·6	7·6	7·2	11	14·6	14	,,
11	5	5·8	5·8	29	9	8·2	8·2	12	17·4	13·8	,,
12	6	6·2	6·2	30	6·8	7·8	7·6	13	13·8	14·2	,,
13	5·2	5·8	5·8	31	10	8·8	8·2	14	10·8	12·8	,,
14	4·4	5·2	5					15	11·8	12·4	..
15	3·8	5·4	4·8	Nov.				16	12·4	12·2	..
16	6·6	6·2	6·2	1	8·2	8·6	8·6	17	10	11·6	..
17	6·2	6·8	6·6	2	8·8	9	8·6	18	13·4	12	..
18	5·6	6·2	6·4	3	10·2	9·2	9	19	11·2	11·8	..
19	5	6	5·6	4	10	9·2	9	20	..	..	..
20	3·8	5·8	5·2	5	10·8	10·2	9·4	21	..	..	..
21	4	5·2	4·4	6	8·8	10·2	9·6	22	..	..	..
22	4·6	5·2	5	7	9	10·2	9·6	23	..	..	..
23	5·6	5·4	5·2	8	9	10	8·6	24	..	..	..
24	5	5·4	5·4	9	6·6	8·6	8·2	25	..	..	..
25	4·2	5·2	5·2	10	6·6	8·8	8	26	..	..	..
26	6·8	5·8	5·2	11	7·6	9	8·2	27	..	..	..
27	6·2	5·8	5·4	12	11·2	9·4	9	28	..	..	..
28	5·4	5·4	5	13	9	10	9·8	29	..	..	..
29	2	4·2	4·2	14	9·6	10	9·6	30	..	..	..
30	5·8	5·2	5	15	7·2	9·4	8·2	31	..	..	..

RAINFALL FROM JULY TO DECEMBER, 1905.
(Recorded at 9 a.m. daily.)

July.	Rain-fall in Inches.	Aug.	Rain-fall in Inches.	Sept.	Rain-fall in Inches.	Oct.	Rain-fall in Inches.	Nov.	Rain-fall in Inches.	Dec.	Rain-fall in Inches.
1	..	1	0·040	1	0·045	1	..	1	..	1	0·040
2	..	2	..	2	2·320	2	..	2	..	2	..
3	..	3	..	3	0·980	3	..	3	0·130	3	..
4	0·020	4	..	4	0·380	4	..	4	0·500	4	..
5	..	5	..	5	0·020	5	..	5	0·015	5	0·025
6	0·010	6	..	6	0·020	6	..	6	..	6	0·170
7	..	7	..	7	0·005	7	..	7	0·275	7	..
8	..	8	0·020	8	..	8	..	8	0·250	8	..
9	..	9	0·020	9	0·030	9	0·025	9	0·515	9	..
10	..	10	0·035	10	0·095	10	0·630	10	0·070	10	0·045
11	..	11	..	11	0·155	11	0·030	11	0·020	11	..
12	0·150	12	..	12	0·010	12	..	12	..	12	..
13	0·115	13	..	13	..	13	1·400	13	..	13	..
14	..	14	..	14	0·095	14	0·010	14	0·030	14	0·040
15	..	15	..	15	0·070	15	0·020	15	0·605	15	0·905
16	0·035	16	..	16	0·075	16	..	16	0·350	16	0·430
17	0·040	17	..	17	0·025	17	..	17	..	17	..
18	0·040	18	0·015	18	0·080	18	0·060	18	..	18	..
19	..	19	0·055	19	0·075	19	..	19	..	19	..
20	0·015	20	0·185	20	0·005	20	0·710	20	..	20	..
21	..	21	..	21	0·480	21	0·060	21	..	21	..
22	..	22	0·020	22	0·800	22	0·620	22	0·045	22	..
23	..	23	0·010	23	0·780	23	0·535	23	0·030	23	..
24	..	24	0·095	24	0·125	24	0·430	24	0·085	24	..
25	..	25	0·080	25	0·005	25	0·020	25	..	25	..
26	0·025	26	0·010	26	..	26	0·025	26	0·080	26	..
27	0·110	27	..	27	0·085	27	0·970	27	0·020	27	..
28	0·155	28	..	28	0·025	28	0·340	28	0·330	28	..
29	0·030	29	..	29	0·060	29	0·120	29	..	29	..
30	0·130	30	..	30	0·005	30	0·140	30	0·180	30	..
31	0·195	31	0·030	..	..	31	0·010	..	..	31	..
Totals..	1·070	..	0·615	..	6·850	..	6·155	..	3·530	..	..
Max. ..	0·195 on 30th	..	0·185 on 20th	..	2·320 on 2nd	..	1·400 on 13th	..	0·605 on 15th	..	..
Number days rain	14	..	13	..	27	..	19	..	18	..	

EXPLANATION OF PLATES LV–LIX.

PLATE LV.

Development of lemon sole (*Ammotretis rostratus*). Figs. *a–c* × 16; *d–j* × 32.

Fig. *a.* Egg, twenty hours after fertilisation.
Fig. *b.* „ forty-eight „
Fig. *c.* „ fourth day after fertilisation.
Fig. *d.* „ fifth day „
Fig. *e.* „ sixth day „
Fig. *f.* „ ninth day after fertilisation (just hatching).

Fig. *g*. Fry, newly hatched out.
Fig. *h*. ,, second day, ventral aspect, yolk-sac uppermost.
Fig. *i*. ,, third ,,
Fig. *j*. ,, fifth ,,

PLATE LVI.

Fig. *a*. *Ammotretis rostratus*, fry, eighth day after hatching
Fig. *b*. Blue-cod (*Parapercis colias*), egg; × 20.
Fig. *c*. ,, larva just hatched out.
Fig. *d*. Pig-fish (*Congiopodus leucopœcilus*), just before hatching.
Fig. *e*. ,, larva, eighth day.

PLATE LVII.

Sketch-plan across Otago Harbour at Port Chalmers.

PLATE LVIII.

View of ponds, looking north-west to Port Chalmers.

PLATE LIX.

Laboratory.

ART. LXII.—*On the Treatment of Partially Decomposed Pyritic Tailings by the Cyanide Process.*

By H. FRANK SHEPHERD.

Communicated by Professor James Park.

[*Read before the Otago Institute, 14th November, 1905.*]

THE first stage in the weathering of tailings or sands containing sulphides of iron is the decomposition of the sulphides into sulphates and free sulphuric acid. When clayey matter is present in the sands sulphate of alumina is formed. The next stage in the decomposition is the oxidation of the sulphates into oxides. Consequently, when mineralised tailings have been exposed to the weather for any length of time they will be found to contain sulphates, oxides, and sulphides in various stages of decomposition.

Soluble sulphates and freshly formed oxides possess a much more injurious effect on solutions of potassium-cyanide than fresh, clean sulphides. Hence, in the treatment of piles of mineralised tailings the first thing to be considered is the best means of getting rid of the sulphates and oxides.

The method of handling and successfully working old pyritic tailings at our plant in Coromandel was as follows: With a good jet of water the tailings were broken up and washed through a $\frac{1}{4}$ in. or $\frac{3}{8}$ in. screen, then lifted with an ejector and run into the tanks through a distributor. This broke up the material and removed the sulphates, while most of the oxides, being held in suspension, passed off with the overflow water. When the tank was filled the percolation-tap was opened and the tailings washed with water until no trace of acid was to be found in the washings. I found that a very reliable and convenient method of determining when the tailings had been sufficiently washed was to take a little working cyanide-solution in a beaker and to add to it some of the water to be tested. A resulting blue or brown colour indicated that more washing was required. The washing must always be continued until the test gives no colour.

When the tailings had been sufficiently washed they were transferred to another tank. First a layer of tailings 2 in. thick was placed on the filter-cloth, then a layer of shell or stone lime at the rate of about 10 lb. to the ton of tailings, then a layer of from 6 in. to 12 in. of tailings followed by another layer of lime, and so on until the tank was filled, in every case finishing with a layer of lime on the top. By this method of working heavily mineralised decomposing tailings were successfuly treated with a 0·4-per-cent. solution of cyanide.

The causes which led me to put the lime in layers were the low bullion-extractions and the high cyanide and zinc consumption when the sands were treated in the ordinary way. Besides, the reaction going on in the extractor-boxes was so strong as to cause the zinc to become brittle, thereby tending to form an undue proportion of zinc-fines.

The bullion-slimes from the extractors were very low-grade, and on investigation this proved to be chiefly due to the presence of iron and alumina. The oxides of these metals left in the tailings after washing in some way passed into solution, and became deposited in the extractors on the zinc. I concluded that the presence of these oxides was the cause of the whole trouble, for the following reasons:—(*a.*) A small quantity of iron and alumina would saturate a 0·4-per-cent. cyanide solution and thus render it incapable of dissolving the gold. (*b.*) In dissolving the oxides the consumption of cyanide would be increased. (*c.*) In precipitating the iron from the solution a strong reaction would be set up in the boxes, thus causing the zinc to become brittle and broken.

It was to overcome these difficulties that I put the lime in layers through the tailings. I found that the solutions in passing through the tailings became partly saturated, and, when in contact with the layer of lime, deposited the iron and alumina, being thereby regenerated and made capable of again dissolving bullion. Thus the solutions passing through the alternate layers of tailings and lime were alternately exhausted and regenerated. Moreover, the layer of lime near the bottom of the tank rendered the solution in good condition for the extractor-boxes.

By this method of treatment the following results were obtained: (*a*) The reaction in the extractors was rendered normal; (*b*) the bullion-extractions were all that could be desired; (*c*) the cyanide-consumption was reduced from 4s. to 1s. 6d. per ton; (*d*) the zinc-consumption was reduced to about one-quarter; besides, there was a much less quantity of slimes to handle.

Art. LXIII.—*Geological Notes on the Country North-west of Lake Wakatipu.*

By Dr. P. Marshall.

[*Read before the Otago Institute, 14th November,* 1905.]

The country to the west of Lake Wakatipu has been but seldom visited. It has, however, been twice reported on in a general way by geological observers.

Professor Park in 1887 made a flying reconnaisance through the district, and gave a general description of the geological formations he met with in the Reports of the Geological Survey. Professor Ulrich in 1890 published in the "Quarterly Journal of the Geological Society" a general account of the rocks of the district, compiled from examination of specimens collected by several explorers.

An expedition was made in January, 1905, by myself, with a party of students from the Otago University School of Mines, and Mr. A. E. Flower, of Christ's College. As the district is still without any tracks, and is traversed by mountain-ranges of an extremely precipitous nature, while the valleys support a dense growth of forest, it was recognised that difficulties greater than those that usually impede a geologist would have to be encountered. Fifteen days' provisions were taken, as well as an ordinary camping-outfit, so each man had to carry a load of 45 lb. at the start. The object was to cross over to the west coast *via* the Rock Burn, Hidden Falls, Olivine, and Pyke Streams. and to ascend the Red Hill Mountain of olivine formation. The weather experienced entirely prevented this result, and the expedition was unable to proceed much further than the head of the Olivine Stream. Geological and physiographical observations were made on the way, in the hope that some additional information might be gleaned as to the origin and nature of the surface features and structure of this out-of-the-way part of the country.

The valley of the Rock Burn proved to be in all its features one of the typical glacial valleys of the west of Otago. Bounded by precipitous mountains rising to 6,000 ft. or 7,000 ft., on the sides it exhibited well the typical U shape of such valleys. At no point is this valley entered by a tributary at its own level. Its waters are fed by tributaries that enter its valley over waterfalls. They are true hanging valleys. The floor of the valley is comparatively flat—about a quarter of a mile wide; it is covered with dense forest except in its upper portions, and everywhere it is strewn with immense angular blocks of rock, some morainic in their origin, others have fallen from the frowning cliffs above. Covered as they are with dense growth of ferns and forest, they offer formidable obstacles to the traveller, and the difficulties taken together often limit the rate of progress to half a mile per hour, even when strenuous exertions are made. From time to time steps in the floor of the valley were met with; over these the stream rushes with impetuous fury, but has cut but a narrow gap in the rock of which the floor is formed. These steps are a result of a sudden increase in the erosive power of the glacier which filed out the valley. The increase is usually due to the addition of a further quantity of ice from a small tributary, which made a material difference to the weight of ice, and hence the power of erosion of the glacier beneath the junction of the tributary. The valley is about fifteen miles long, and in this distance its bed descends from an altitude of 3,520 ft. to 1,150 ft. where it enters the Dart. The valley terminates in a cirque, with precipitous walls on the north and east, but on the west the slope is more gentle.

On the east side the snout of a glazier terminates at an elevation of 1,200 ft. above the valley-floor. The glacier supplies the greater portion of the water of the Rock-burn Stream. The east side of the valley is usually 65° in slope. It is often a flat, bare surface coincident with the foliation plane of the schist.

The west side of the cirque is comparatively low, rising to only 4,490 ft. The west, therefore, forms a low pass over the Humboldt Range. The pass is only a quarter of a mile wide, and then descends precipitously to the valley of the Hidden Falls Stream, whose bed is here 1,000 ft. lower than that of the Rock Burn, the barometer giving a reading of 2,560 ft. above sea-level.

There is no bush in the Rock Burn Valley at a greater height than 3,000 ft., but on the east side of the Hidden Falls Valley it rises to 4,000 ft. The valley of the Hidden Falls is less U-shaped than that of the Rock Burn. This is mainly due to the huge slips and scree slopes that have broken away from the steep faces and litter the sides of the valley.

The Hidden Falls Stream obtains most of its water from glaciers on the Barrier Range. The snouts of the glaciers are about 1,000 ft. above the valley-floor, and, as in the case of the Rock Burn, the waters from their melting ice tumble down precipices into the valley below. This ice fills hanging valleys from which ice was under other conditions supplied to the main valleys.

From the head of the Hidden Falls Stream there is a low, flat pass with mountain walls on either hand to the head of the Olivine Stream. On the west side a mountain wall rises without a break, but on the east deep valleys cut far into the hills, and each appears to terminate beneath the snout of a glacier, though we were unable to spend the time necessary to prove this in every case. There can be no doubt that all the flat of this deep pass was once covered by ice, for in many points of vantage on the mountain-side perched blocks, evidently of a different nature from that around them, are to be seen. A large mass of moraine extends across the top of the Olivine Stream. This dammed up the stream, and is the main cause of the formation of the wide flat area of the pass beyond it.

The Olivine Stream is in all essentials a duplicate of the Rock Burn. Its main features are certainly due to glacial erosion.

From the Olivine there is a low saddle leading to the valley of Lake Alabaster. The slope on the Olivine side is extremely steep, and that stretching towards Lake Alabaster also appears precipitous. On the saddle itself the effects of ice-action are clear and pronounced. Rounded and worn rock-surfaces are everywhere in evidence, though the actual grooves and polished surfaces are here, as elsewhere, somewhat indistinct.

The profound valley occupied by Lake Alabaster is entered by the Pyke River from the north-east. This river is, at a distance of twenty-five miles above Lake Alabaster, separated from the waters of Big Bay by a flat area of morainic matter no more than 200 ft. above sea-level. This morainic matter fills a wide valley between the Skipper's and McKenzie Ranges. The Pyke River, instead of following this obvious straight course to the sea, turns sharply to the south-west towards Lake Alabaster, joins the Hollyford River, and after a course of thirty-five miles enters the ocean near Martin's Bay.

Evidently some special explanation of this eccentricity is required. The explanation is to be found in a consideration of the movements of the ice of the great Hollyford glacier. This prehistoric glacier received the ice from twenty-five miles of mountain-ranges on either hand, and, judging from the depth and width of its valley, must have attained enormous dimensions. In the lower part of its course the ice-stream underwent "diffluence," and a portion of it passed over a low saddle then occupying the site of Lake Alabaster, and entered the sea at Big Bay. The ice that followed this course was of great quantity, and soon eroded the saddle away, and formed the deep basin of Lake Alabaster on its way. As in this low country the ice would be gradually melting away, a "reverse" slope would be formed, and if the terminal face were near the sea in Martin's Bay morainic matter would be deposited there. Finally, when the climate became more genial and the ice melted, the streams that took the place of the glaciers were blocked from Big Bay by the moraine, and flowed down the reverse slope to Lakes Alabaster and Mackerrow, whose waters were then continuous. Since then the detritus carried down by the Hollyford has advanced for and separated Lakes Mackerrow and Alabaster from one another. The course of the upper part of the Pyke, of the Olivine, and Barrier Streams clearly points to Big Bay as the original outlet for their water or their ice.

The complete filling of the Hollyford Valley with ice also appears to offer an explanation of the formation of the remarkable flat pass between the Olivine and Hidden Falls Streams. This would decrease the grade down the Hidden Falls Valley, for the surfaces of tributary and main ice-streams are always on the same level, consequently the flow of ice was partly dammed back, and some of it flowed over a saddle into the Olivine and eroded it to its present low level. Still further on some of this ice appears to have passed over gaps from the Olivine to the Alabaster Valley, where the level of the ice-surface, owing to the small amount of gathering-ground in that locality, and its proximity to the glacier-snout, was less.

One important fact in regard to the physiography of this region is the very different levels of streams on opposite sides of mountain-ridges. For instance, the Rock Burn floor is 1,000 ft. higher than that of the Hidden Falls Stream, on the other side of the pass. The Olivine floor is 3,500 ft. above Lake Alabaster, though only separated from it by a narrow rock ridge. Instances might be multiplied indefinitely. They seem to point to the probability that here some cause has completely upset the usual drainage conditions of areas of high land. Since this disturbing agent has ceased to act the normal relations of drainage valleys and systems have not been established, because sufficient time has not yet elapsed.

That ice is capable of just this disturbance that is here found I believe to have been fully established by geologists. To my mind no writer has more fully stated the peculiarities of glacial valleys than Professor A. Penck, of Vienna, and Professor W. M. Davis, of Harvard. More especially has this been done lately in the "Journal of Geology," where Professor Penck, writing on the "Glacial Features on the Surface of the

Alps," has described facts that are point for point repeated time and again in the glacial regions in the south-west of Otago. It is inconceivable to me that earth-movements, sudden or gradual, could account for the many peculiar physiographical features which have been alluded to in the previous pages.

The general geological structure of the district is indicated in the small sketch-map on p. 566. It is here advisable only to state that the district is one of mica-schist and phyllites, with a dip and strike that varies little throughout the area. Their age is still doubtful, for while Captain Hutton has lately classed them as of Archæan formation, Sir James Hector has classed them as Silurian, and other divergent statements are not wanting. Through this schist there is intruded an igneous mass which outcrops at the Olivine Saddle, as afterwards described.

The following rock-types have been distinguished, and their petrographical characters are described :—

Diorite.—Bryneira Saddle, between Olivine Creek and Lake Alabaster. Hand-specimen medium-grained. Hornblende and feldspar can be distinguished. Section: All the feldspar is completely saussukitised, and the hornblende is uralitic. The exact original nature of this rock can only be guessed at.

Gabbro.—Cow Saddle. A coarse-grained rock showing decomposed feldspar and large cleavage-surfaces of diallage. In section the diallage is fairly fresh, but the feldspar is completely changed into saussurite.

Pyroxenite.—Cow Saddle. Cleavage surfaces of diallage numerous and conspicuous. The mineral appears to constitute nine-tenths of the rock. In section the spaces between the diallage-grains are small, and are entirely filled with serpentine, mingled with which is some pyrite.

Lherzolite.—Cow Saddle. A pale-yellow rock showing many cleavage surfaces of a pyroxene imbedded in the olivine. Sections show large irregular grains of olivine nearly fresh. Pyroxene, both monoclinic and orthorhombic, is present. The former is a very pale-green, and is referred with certainty to diopside. The orthorhombic pyroxene is quite colourless, and is certainly enstatite. In addition there is a fair quantity of a yellow mineral with a high index of refraction. It is far more transparent than the chromite of the dunite of Nelson and of Milford Sound, and is probably a chrome picotite. The mineral has not yet been separated for analysis. This description of the rock will be found to agree satisfactorily with the description of rocks from the Red Hill by Professor Ulrich.* In this description,

* Quart. Journ. Geol. Soc., vol. xlvi, 1890, p. 627.

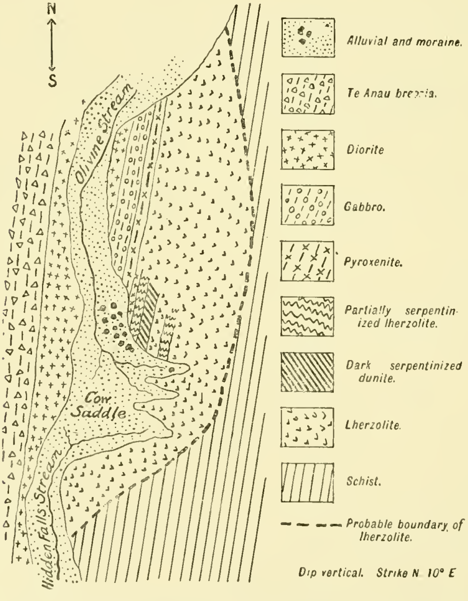
however, the green mineral that was evident in hand-specimens was not represented in any of the sections, and Professor Ulrich provisionally referred it to enstatite, which was present in quantity. Ulrich referred the rock to the group of saxonites of Wadsworth—that is, the hartzbergites of Rosenbusch and other authors. The demonstration of the fact that the green mineral is diopside, which is easily done in the sections now before me, justifies the classification of this rock with the lherzolites. A section of this rock was sent some months ago to Professor Rosenbusch of Heidelberg. The section, however, was in some respects exceptional, for but little olivine was present; and Professor Rosenbusch stated that the rock was a websterite, a connecting-link between the hartzbergites and the pyroxenites. A partial cataclastic structure was also remarked upon. Seeing that in the greater part of the rock olivine is very abundant, I feel justified in classing the rock with the lherzolites in spite of the statement of the eminent authority. I would wish, however, to put on record my deep sense of gratitude to Professor Rosenbusch for the kindness and assistance that he has so readily extended to me.

Dunite.—A large mass of the rock is of a dark-slate colour, weathered on the surface to a dull-brown. In hand-specimens it appeared perfectly dense; sections, however, showed at once that the rock is really a dunite in process of serpentinisation. A little chromite and pyroxene are present, but the greater portion is a mass of olivine-grains traversed in all directions by small veins of serpentine, forming a very complete mesh structure.

The arrangement of these rocks is shown in the plan on the following page.

The weather effectually prevented an exact demarcation of the boundaries of the different rock-types, and the approximate boundary of the lherzolite was made out observing the colour of the rocks where they emerged above the snow in the distance.

It will be noticed that the igneous rocks are bounded by schists on the east and by the Te Anau breccia on the west. The latter, however, may quite possibly be the effusive type and associated fragmentary rocks of the diorite magma adjacent to it. From the boundary of the diorite there is a regular increase of basicity until the lherzolite is reached. At the south end of the area the lherzolite is certainly in direct contact with the schist on the east side. So far as could be seen the division-lines between the different rocks correspond in direction and inclination with those of the schist. If this should finally prove to be the case, further work will be necessary to decide whether the igneous mass was a laccolite that has since been subject to the same folding movements as the surrounding rocks, or whether the mass is an intrusion formed subsequent to the main rock-movements of the region. The apparent abrupt change on the last from lherzolite to schist, and the gradual change of rock-type to the west, seem to support the former view. At any rate it is apparent that here there is abundant material for studying the differentiation of a magma from which rocks varying from diorite to lherzolite have crystallized. However, the exceeding remoteness of the locality, the roughness of the country, and the great difficulty of obtaining supplies render it unlikely that the district will be revisited for some time, hence it was considered advisable to place on record even these vague and ill-determined facts.



The probable transition from the peridotite type to gabbro was already supposed by Professor Ulrich, from information supplied by Butement, who had gathered it from observations made nearer the coast-line.

The expedition to this region was made with the object of making observations on the nickel-iron alloy awaruite; but so far as that object was concerned it was without result. No awaruite was found, and no nickel could be found in the rock when chemical tests were made. It appears, therefore, that awaruite does not occur in the peridotite rocks of the south end of this extensive magnesian region.

The relationship of this area to the magnesian rocks of Milford Sound, described by me last year, is not a very close one, though of course the two olivine rocks belong to the same group and occur in the same petrological province. The dunite of Milford Sound contains much darker chrome-ore, and is almost destitute of diopside. The hartzbergite of Milford Sound contains a chrome-bearing magnetite, but no picotite or chromite or diopside. In the present peridotite the picotite is pale-coloured, diopside is abundant, and enstatite less frequent.

RECORDS OF MILNE SEISMOGRAPHS.

Records of the Milne Seismographs Nos. 16 and 20, taken at Christchurch and Wellington, by Mr. Skey and Mr. Hogben.

Communicated by Mr. G. Hogben, M.A.

Plates LXI.–LXVII.

Records of Milne Seismograph No. 16, at the Magnetic Observatory, Christchurch, New Zealand.

Latitude, 43° 31′ 50″ S.; longitude, 172° 37′ 18″ E. Time employed: Greenwich mean civil time.

Time, G.M.C.T., as stated above. P.T., preliminary tremors less than 2 mm. complete range; A.T., after-tremors less than 2 mm. complete range; B., E., beginning and end of vibrations not less than 2 mm.; Amp., half-range in millimeters.

H. F. Skey, Observer.

Date.		P.T. from	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. till	B.P.	Remarks.
1905.		H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H. m.	Secs.	
January	7	2 30·1	..	2 34·3	..	0·6	..	3 20·6	..	
"	8	..	..	23 07·9	..	..	..	..	..	Minute.
"	13	..	..	13 48·9	..	2·8	..	..	..	In the middle of large night tremors.
"	19	21 54·2	22 00·4	22 01·4	..	3·25	22 03·5	23 31·6	..	
"	20	22 58·3	..	23 04·0	..	0·8	..	23 25·5	..	
"	22	2 54·4	3 07·9	3 26·5	3 28·1	5·05	3 38·9	5 16·1	..	
"	22	9 27·7	..	9 29·3	..	0·9	..	9 52·0	..	

February	1	2 21·4	..	2 26·1	..	..	..	2 28·7	..	Very slight.
"	13	Indefinite	5 44·0	5 46·1	..	2·45	5 51·8	7 17·6	..	P.T. came while attending to instrument, between 5.36 and 5.40.
"	13	23 32·0	23 36·2	23 41·4	..	4·45	23 43·2	1 04·1	..	
"	14	1 13·4	..	1 17·5	..	0·7	..	1 34·1	..	
"	14	9 12·9	9 40·1	9 41·3	..	1·29	10 08·2	Indefinite	..	A.T. obscured by night tremors.
"	15	0 00·2	..	0 04·3	..	..	..	0 06·4	..	Very slight.
"	15	1 35·9	..	1 40·0	..	1·4	..	2 13·7	..	
"	19	4 44·4	4 50·6	4 53·7	4 59·4	12·45	5 19·5	7 03·8	..	
"	20	11 50·7	..	11 58·7	..	..	..	12 08·2	..	Very slight.
"	20	..	..	13 23·3	..	..	..	..	..	Thickening merely.
"	20	14 22·0	..	14 30·5	..	..	..	Indefinite	..	Very slight. A.T. obscured by night tremors.
"	21	4 00·6	..	4 05·0	..	..	..	4 08·3	..	Thickening of line.
"	26	2 38·1	2 45·4	2 46·4	..	2·5	2 50·8	Indefinite	..	
"	26	4 21·6	..	..	..	..	..	..	..	Short, sharp shocks.
"	26	4 38·1	..	..	..	..	..	..	..	"
	26	5 03·0	..	..	..	..	..	5 06·0	..	Very slight, thickening.
"	27	Indefinite	17 32·6	17 39·6	..	3·5	18 00·3	Indefinite	..	P.T. and A.T. obscured by night tremors.
March	4	Indefinite	16 28·1	16 29·4	..	2·3	16 38·9	Indefinite	..	Ditto.
"	4	Indefinite	18 53·6	19 00·7	..	2·4	19 06·9	Indefinite	..	"
"	4	23 25·5	23 40·0	23 44·6	..	7·4	24 07·9	Indefinite	..	A.T. obscured by second quake.
"	5	Indefinite	0 59·6	1 03·9	..	2·0	1 05·3	2 20·8	..	P.T. obscured by previous quake.
"	17	2 00·7	..	2 02·8	..	0·45	..	2 23·5	..	
"	19	0 03·7	0 09·4	0 18·0	0 18·7	17·0+	1 39·4	3 50·3	..	
"	19	4 19·3	..	4 24·4	..	0·3	..	4 30·3	..	Very slight.
"	19	11 53·9	..	11 59·6	..	0·3	..	12 18·2	..	"
"	19	13 09·9	..	13 15·6	..	0·05	..	13 23·9	..	"

RECORDS OF MILNE SEISMOGRAPH No. 16—*continued.*

Date.		P.T. from	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. till	B.P.	Remarks.
1905.		H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H. m.	Secs.	
March	22	4 02·7	4 29·6	4 30·1	..	1·9	5 12·6	6 38·9	..	
"	27	7 55·6	..	8 12·1	..	0·6	..	8 50·9	..	
April	2	Indefinite	..	1 45·7	..	0·5	..	Indefinite	..	In the middle of continuous tremors.
"	4	1 10·0	1 25·9	2 08·0	..	8·5	3 21·0	5 17·4	..	Origin northern India.
"	9	4 55·4	..	5 02·1	..	0·3	..	5 11·9	..	
"	19	Indefinite	12 43·9	12 47·5	..	2·55	12 56·8	..	..	P.T. and A.T. obscured by night tremors.
"	25	9 34·6	9 39·8	9 41·9	..	1·3	9 42·9	..	..	A.T. obscured by night tremors
May	11	Indefinite	17 45·9	17 48·0	..	1·5	17 50·1	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	15	4 05·4	..	4 09·0	..	0·5	..	4 24·5	..	
"	17	23 17·9	..	23 26·1	..	0·7	..	24 11·1	..	
"	18	Indefinite	14 00·8	14 11·2	..	6·9	14 37·5	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	23	6 42·6	..	6 59·4	..	0·55	..	8 08·7	..	
"	25	3 47·0	..	4 03·6	..	0·5	..	4 33·6	..	
June	1	..	..	21 07·8	..	0·9	..	..	..	In the middle of continuous tremors.
"	9	Indefinite	12 44·5	12 53·8	..	2·35	12 56·3	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	11	5 22·5	5 22·6	5 31·8	..	2·9	5 42·7	6 53·5	..	

June	14	Indefinite	11 36·9	11 46·6	..	17·0+	12 20·4	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	16	9 40·0	..	9 49·4	..	0·75	..	10 37·2	..	
"	17	21 01·6	..	21 13·9	..	0·3	..	21 32·7	..	
"	21	7 43·2	..	7 46·4	..	..	..	7 52·6	..	Very slight.
"	29	7 31·5	..	7 38·8	..	0·3	..	7 46·5	..	
"	30	17 13·1	17 18·3	17 24·4	17 24·9	17·0+	18 29·9	19 29·5	..	
July	1	1 01·8	1 22·4	1 24·4	..	2·1	1 26·5	2 10·0	..	
"	9	Indefinite	10 30·2	11 20·4	..	2·85	11 32·5	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	11	15 57·2	..	16 08·6	..	0·35	..	16 47·9	..	Swellings merely.
"	17	0 29·4	0 36·7	0 38·2	..	1·5	0 39·3	2 06·7	..	
"	23	3 06·8	3 17·2	4 19·3	..	5·8	5 28·6	7 19·3	..	
"	27	..	..	23 23·0	..	..	..	..	..	Very slight swelling.
"	31	..	..	9 03·5	..	..	..	..	..	"
August	4	..	..	7 51·7	..	..	..	..	..	"
"	8	Indefinite	13 21·6	13 23·2	..	10·3	13 38·6	Indefinite	..	P.T. and A.T. obscured by night tremors.
"	11	..	..	..	..	..	..	..	..	Small tremor-storm between 21 57·3 and 22 57·3.
"	12	13 20·6	..	13 22·9	..	..	..	Indefinite	..	A.T. obscured by night tremors
"	15	..	..	4 42·1	..	..	..	..	..	Very slight.
"	15	Indefinite	..	8 12·1	..	0·8	..	Indefinite	..	P.T. and A.T. obscured by night tremors.

Records of Milne Seismograph No. 20, at Wellington, from January, 1905, to December, 1905 (inclusive).

Latitude, 41° 17′ S.; longitude, 174° 47′ E. Greenwich mean civil time. Midnight, 0 h. or 24 h.; hours, 1 to 24. Time in hours, minutes, and tenths of minutes.

P.T., preliminary tremors. A.T., after-tremors. Beg., long waves begin. Max., beginning of maximum phase. Last Phase, beginning of last phase. Amp., half range in millimeters.

The instrument is placed in a special room below a house standing about 30 ft. from the edge of a rocky cliff about 50 ft. high, situated about 250 yards from the shore-line of Wellington Harbour.

George Hogben, Observer.

Date.		P.T. (from)	Long Waves.			Amp.	End.	A.T. (till)	B.P.	Remarks.
			Beg.	Max.	Last Phase.					
1905.		H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H. m.	Secs.	
January	13	13 31·1	13 35·2	..	..	2·7	13 55·2	14 33·8	17·0	
"	19	21 35·4	..	21 57·2	..	4·0	..	..	..	
"	20	..	..	22 43·9	..	0·5	..	..	..	Probably N.Z. origin.
"	20	22 57·3	..	22 59·1	..	0·8	23 02·5	..	..	
"	22	2 52·8	3 01·2	3 11·3	..	5·0	3 40·1	{ 5 12·1* 5 16·9 }	..	* Probably long waves along major arc.
"	23	8 05·1	..	8 09·2	..	0·5	..	..	..	
February	7	19 12·9	19 32·7	19 35·9	..	1·6	?	..	17·0	End obscured by tremors.
"	27	..	17 30·4	17 37·3	..	2·0	..	18 50·4	..	

March	18	23 13·5	..	24 10·4	..	> 20·0	..	..	16·9	"Repeats" at 3 16·9 and 4 18·5 (March 19)
"	22	?	?	4 33·3	..	7·0	?	..	..	Beg. and end obscured by tremors.
"	27	..	..	21 48·8	..	0·5	..	..	..	N.Z. origin.
"	27	..	..	22 23·8	..	0·4	..	..	..	"
"	28	..	..	2 03·8	..	0·5	..	..	..	"
"	28	7 49·6	7 52·3	7 53·7	..	0·6	..	..	16·9	
April	4	{ 1 09·8 / 1 17·5 }	2 01·3	2 08·9	2 29·6	13·0	..	7 33·5	17	Origin near Kangra, northern India.
"	19	12 35·6	..	12 40·7	..	2·2	13 06·3	..	..	
"	25	..	..	16 41·0	17 04·3	0·5	..	..	..	
"	28	15 26·8	15 58·7	16 15·2	..	0·6	..	17 29·6	..	Several "repeats."
May	12	..	16 23·0	..	..	0·9	..	..	..	Long, slow movement.
"	18	13 45·9	14 02·1	14 05·3	..	8·2	..	..	..	
June	14	10 55·3	11 34·5	11 42·2	..	> 20·0	..	..	..	
"	16	8 51·5	9 05·8	9 32·9	..	1·2	..	..	..	
"	20	10 50·0	19 12·5	..	..	0·6	..	..	..	Many tremors and small shocks, not all local.
"	23	..	..	..	20 31·4	2·0	..	..	..	
"	24	..	..	..	..	..	..	7 30·0	..	
"	30	17 11·6	17 16·8	17 19·0	..	> 20·0	..	..	..	
July	6	16 43·5	17 16·2	17 26·1	17 42·9	1·1	..	..	..	
"	9	9 37·4	11 15·1	..	..	3·0	..	..	..	Case opened just after beg. of P.T.
"	9	17 10·8	17 12·9	..	..	0·7	..	..	..	Origin near N.Z., probably east.
"	10	3 20·9	3 22·0	..	..	1·0	..	..	..	Ditto.
"	17	?	1 31·3	1 34·9	1 56·1	2·5	..	?	..	
"	23	2 58·6	4 01·6	4 13·0	4 55·8	7·5	..	..	16·2	Origin near Chita, Siberia.
"	24	9 06·7	..	9 22·0	..	1·5	..	..	..	
"	24	21 54·3	..	22 12·8	..	1·5	..	..	..	

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

Date.		P.T. (from)	Long Waves.			Amp.	End.	A.T. (till)	B P.	Remarks.
			Beg.	Max.	Last Phase.					
1905.		H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H. m.	Secs.	
July	26	20 22·8	..	21 33·6	..	1·0	..	..	..	
"	31	7 44·2	..	7 46·0	..	3·2	..	..	..	Origin near N.Z., probably east.
August	8	12 43·4	13 18·7	13 20·6	..	7·2	..	15 13·9*	..	* Probably long waves along major arc.
"	17	19 13·4	19 34·9	19 40·1	..	0·7	..	..	..	
"	20	..	3 55·4	3 57·3	..	0·9	..	..	..	Origin probably N.Z.
"	20	..	..	5 18·8	..	0·4	..	..	..	Origin N.Z.
"	20	6 40·1	..	6 44·2	.	..	..	..	..	Near N.Z., probably east coast origin.
"	22	?	..	3 45·2	..	1·1	..	?	..	
"	23	2 58·6	4 00·9	{ 4 06·9 4 13·0 }	..	8·5	..	..	..	Very distant origin.
September	8	?	2 08·1	2 26·1	..	*	2 41·8	..	..	* Only thickening of line.
"	15	6 20·5	..	6 34·9	..	0·7	..	..	..	
"	29	12 04·5	12 08·7	12 14·1	12 22·9	1·2	..	..	..	
October	11	..	22 27·4	22 29·2	..	0·5	..	5 54·5*	..	* October 12.
"	21	..	18 42·3	18 51·5	..	0·5	..	..	..	Origin (?) near Constantinople.
November December	}	..	..	..	..	..	..	..	..	No shocks except small local ones.

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

THIRTY-SEVENTH ANNUAL REPORT.

The annual meeting of the Board of Governors was held on the 24th January, 1906, in the Colonial Museum, Wellington, and was attended by fifteen members.

The Council reported that at the annual meeting held on the 19th January, 1905, the following officers were re-elected: President — Captain Hutton, F.R.S.; Treasurer — Mr. J. W. Joynt, M.A.; Secretary—Mr. T. H. Gill, M.A., LL.B.; Editor of the Transactions and Librarian—Mr. A. Hamilton.

The members now on the roll are—Honorary members, 28; Auckland Institute, 164; Hawke's Bay Philosophical Institute, 56; Wellington Philosophical Society, 117; Philosophical Institute of Canterbury, 124; Otago Institute, 105; Nelson Institute, 24; Westland Institute, 55; Manawatu Philosophical Society, 38: making a total of 709.

The nominations received in accordance with the provisions of the Institute Act are: By the Government—Messrs. A. Hamilton and J. Young; Auckland Institute—Professor Thomas, Mr. J. Stewart; Hawke's Bay Philosophical Institute—Mr. H. Hill; Wellington Philosophical Society—Professor Easterfield, Mr. Martin Chapman; Philosophical Institute of Canterbury—Dr. Chilton, Dr. Farr; Otago Institute—Professor Benham, Mr. G. M. Thomson; Nelson Institute—Dr. Cockayne; Westland Institute—Mr. T. H. Gill; Manawatu Philosophical Society—Mr. W. Welch.

The volumes of Transactions now on hand are—Vol. I (second edition), 319; Vol. V, 35; Vol. VI, 26; Vol. VII, 148; Vol. IX, 219; Vol. X, 141; Vol. XI, 396; Vol. XII, 309; Vol. XIII, 146; Vol. XIV, 111; Vol. XV, 284; Vol. XVI, 274; Vol. XVII, 535; Vol. XVIII, 313; Vol. XIX, 560; Vol. XX, 457; Vol. XXI, 460; Vol. XXII, 566; Vol. XXIII, 575; Vol. XXIV, 676; Vol. XXV, 632; Vol. XXVI, 620; Vol. XXVII, 612; Vol. XXVIII, 696; Vol. XXIX, 599;

Vol. XXX, 693; Vol. XXXI, 704; Vol. XXXII, 527; Vol. XXXIII, 620; Vol. XXXIV, 573; Vol. XXXV, 535; Vol. XXXVI, 700. These are now stored in the Parliamentary Buildings.

The volume for 1904, published June, 1905 (XXXVII), contains sixty-two articles, also short summaries of the proceedings of the various scientific societies affiliated to the Institute. The volume consists of 650 pages and fifty-five plates. A comparison of the contents of Vol. XXXVII with those of Vol. XXXVI is as follows:—

	1904. Pages.	1903. Pages.
Miscellaneous	215	129
Zoology	145	90
Botany	51	169
Geology	143	108
Chemistry and physics	27	11
Records of Milne seismographs ..	8	..
Proceedings	39	23
Appendix	32	38
	650	568

The whole of the work was done at the Government Printing Office.

During the year the Institute in particular and science in general sustained a great loss by the death of Captain Hutton, F.R.S. At the time of his death, which occurred on the "Rimutaka" between London and Cape Town, Captain Hutton was President of the Institute. He was associated with the work of the Institute from its inception, and his labours in the cause of science are well known throughout the colony. The Philosophical Institute of Canterbury, with which Society the late Captain Hutton was more intimately connected, at a recent meeting unanimously passed a series of resolutions requesting the Institute to commemorate the services of our late President by establishing a Hutton Memorial Research Fund.

During the year the standing committee has paid a good deal of attention to the Carter bequest. By the will of the late Charles Rooking Carter certain moneys were vested in the Governors of the New Zealand Institute. The words of the will are, "and as to all the residue and remainder (if any) of the said net proceeds of the sale and conversion and getting in of my estate as aforesaid, my trustee shall transfer the same to the Governors for the time being of the New Zealand Institute at Wellington to form the nucleus of a fund for the erection in or near Wellington aforesaid and the endowment of a professor and staff of an astronomical observatory fitted with telescopes and other suitable instruments for the public use and benefit of the colony, in the hope that such fund may be augmented by gifts from private persons and that the observatory may be subsidised by the Colonial Government." On the 28th February, 1905, the interest and principal amounted to £2,309 15s. 4d., and in addition there is certain scrip in the New Zealand Loan and Mercantile at face-value. The money is invested by the Public Trustee, and is earning interest at the rate of 4 per cent. per annum.

In reply to a resolution passed at the last annual meeting *in re* binding scientific periodicals in the Institute library, the Colonial Secretary has informed the Institute that the sum of £200 has been appropriated by Parliament for that purpose.

The Royal Geographical Society of Australasia, Queensland, celebrate the twenty-first anniversary of the foundation of the society in the last week of June, 1906. A cordial invitation is extended by the Council of the Queensland Society to the New Zealand Institute Board of Governors.

Mr. Henry Suter, of Auckland, asks the Institute to undertake the publication of a new catalogue of *Mollusca* of New Zealand.

All these matters will come up for consideration at this meeting.

Notices of motion dealing with nature-study in public schools and the establishment of a Forestry Board have been received and will need your attention.

The Library Committee and the Publication Committee present separate reports.

MARTIN CHAPMAN, Chairman.

STATEMENT OF THE RECEIPTS AND PAYMENTS OF THE NEW ZEALAND INSTITUTE FOR THE YEAR ENDED 31ST DECEMBER, 1905.

Receipts.	£	s.	d.
Balance from last year	418	1	9
Government grant	500	0	0
Contribution from Wellington Philosophical Society	43	1	6
Sale of "Maori Art"..	49	6	6
Sale of Transactions	7	3	0
	£1,017	12	9

Payments.

	£	s.	d.
Salaries—			
Editor	50	0	0
Secretary	25	0	0
Printing Transactions, Vol. XXXVII	462	16	0
Expenses of library	13	15	0
Travelling-expenses attending meetings	16	19	1
Postage, foreign volumes	6	0	0
Printing, stationery, and binding	15	2	6
Miscellaneous payments	11	3	11
Balance—			
Cash in hand	0	8	7
Cash in bank	416	7	8
	£1,017	12	9

Balance to credit of Carter bequest	£2,421	19	11
(Loan and Mercantile scrip, nominal value.)			

Audited and found correct.

Wm. Beauchamp Platts.

Wellington, 24th January, 1906

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

Annual Meeting: *5th April*, 1905.

Professor Easterfield, President, in the chair.

New Members.—Dr. J. M. Bell, Mr. H. M. Christie, Mrs. H. M. Christie, and Dr. L. Cockayne.

The President announced with regret the death (which took place in February, 1905, at Tamworth, New South Wales) of Mr. Ambrose Quail, a former member of the Society, and an occasional contributor of papers to the Transactions.

Mr. G. V. Hudson said that Mr. Quail's death—of which he now heard for the first time—was a serious loss to science. Formerly a resident of Palmerston North, Mr. Quail had removed some time ago to Queensland. His special branch of study was the minute structure of insects: he might be described as an entomological microscopist. He excelled as a draftsman; and it might safely be said that no better drawings than those of Mr. Quail were to be found in entomological publications. He had been a valued contributor to the "Transactions of the New Zealand Institute," and to the "Transactions of the Australasian Association for the Advancement of Science."

The Secretary, Mr. Thomas King, read the annual report and statement of accounts.

The report stated that seven meetings had been held during the session of 1904, and that the total number of papers read at these meetings had been twenty-two, which exceeded by seven the number read during the preceding session. The roll had been purged by the deletion of the names of a number of persons who had ceased to be members by reason of the non-payment of their subscriptions. Three members had resigned during the year, and eight new members had been elected. The total membership was now 104.

The receipts, including a balance of £75 6s. brought forward from the previous year, amounted to £163 10s., and the expenditure (including two years' contributions to the funds of the New Zealand Institute) to £119 0s. 5d., leaving a balance in hand of £44 9s. 7d. The Research Fund, on fixed deposit with the Bank of New Zealand, amounted to £39 19s.; so that the total sum at the credit of the Society was £84 8s. 7d.

Election of Officers for 1905.—*President*—Mr. Martin Chapman; *Vice-Presidents*—Professor T. H. Easterfield and Mr. G. Hogben, M.A.; *Council*—Mr. Edward Tregear, Mr. G. V. Hudson, F.E.S., Professor H. B. Kirk, Mr. C. E. Adams, B.Sc., Sir James Hector, K.C.M.G., F.R.S., Dr. A. K. Newman, and Mr. J. W. Poynton; *Secretary and Treasurer*—Mr. Thomas King; *Auditor*—Mr. E. R. Dymock, A.I.A., N.Z.

Responding to a vote of thanks moved by Mr. Martin Chapman, Professor Easterfield, the retiring President, said that he must congratulate the Society on its excellent record of work for the year. Once again he felt it right to remark that in all cases the papers which had come before the Society had been the result of careful work by the authors themselves, and were not merely popular descriptions of other people's work, as was the case with the papers of so many societies. He thought it a sign of great promise that in Wellington, notwithstanding the extreme "business" character of the people, we were able to find a large number of observers capable of contributing something from their own observations. It was work of this kind to which we must ultimately look for the advancement of any branch of science.

Paper.—"Two New Ferns," by H. C. Field. (*Transactions*, p. 495.)

Exhibit.—Professor H. B. Kirk exhibited under the microscope a specimen of a rare species of *Volvox.*

FIRST MEETING: *3rd May*, 1905.

Mr. Martin Chapman, President, in the chair.

Papers.—1. "The Estimation and Detection of the Alkaloids by Means of their Double Sulphocyanides," by P. W. Robertson, M.A., Rhodes Scholar. (*Transactions*, p. 51.)

Professor Easterfield congratulated Mr. Robertson on his investigations, and said that the author's test for the detection of the presence of certain alkaloids was likely to prove a very useful one.

2. "Flints from Miramar" (with exhibits), by Henry M. Christie.

3. "Struggle between a Brown Spider and a Common Worm," by Henry M. Christie.

4. "Capture of an Octopus at Lyall Bay," by Henry M. Christie.

Professor H. B. Kirk gave an account of various biological laboratories visited by him during a recent trip to Europe.

SECOND MEETING: *7th June*, 1905.

Mr. Martin Chapman, President, in the chair.

Papers.—1. "Natural Photography," by Coleman Phillips.

2. "On New Zealand Earthquakes," by G. Hogben, M.A. (*Transactions*, p. 502.)

Mr. A. McKay agreed generally with Mr. Hogben, but desired to point out that while, as Mr. Hogben had argued, the lines of seismic activity in New Zealand were, broadly speaking, parallel to the great fault-lines of the country, yet very many of these lines of faulting (at Okarito, for example) converged upon, and even intersected, one another. Mr. McKay said that the line of activity south of Banks Peninsula to which Mr. Hogben had referred was unknown to himself.

Dr. Newman mentioned that settlers on the east coast of the North Island were of opinion that the country along the coast-line in their district was gradually tilting up. He instanced the experience of a settler, who found that his carts, when loading wool in the surf-boats, had now to negotiate a very different depth of water from that which was the rule some years ago.

Mr. Hogben, in his reply, referring to the case of the settler of whom Dr. Newman had spoken, expressed the hope that we might soon see good bench-marks all round the coasts of the colony, or, failing these, some suitable instruments, such as the simple clinometer recommended by the British Association.

3. "Results of Dredging on the Continental Shelf of New Zealand" (Part I), by Charles Hedley, F.L.S., Sydney; communicated by A. Hamilton. (*Transactions*, p. 68.)

Exhibits.—At the invitation of the Chairman, Mr. A. Hamilton, Director of the Colonial Museum, Wellington, exhibited and described some recent additions to the Museum. Mr. Hamilton also exhibited a wooden tablet from Easter Island bearing lines of hieroglyphics presumably inscribed upon it by the ancient inhabitants of the island.

Third Meeting: *5th July*, 1905.

Mr. Martin Chapman, President, in the chair.

New Member.—Mr. Percy B. Philson.

Papers.—1. "Recent Discoveries of Moa-bones on Miramar Peninsula, Wellington," by Henry M. Christie.

In the discussion which followed the reading of this paper, Mr. Edward Tregear, dealing with the much-debated question of the period at which the moa became extinct, expressed the opinion that at present the whole subject was beset with difficulties: it was impossible to come to a definite conclusion. Although the geologists tried to convince us that within quite recent times the Maoris were feasting on the moa and its eggs on Miramar Peninsula, he himself was not prepared to admit that Maoris living in or near our own times had ever seen the bird. It seemed to him that it must be much more than four hundred years since the moa became extinct.

Mr. A. McKay defended the view that the moa had survived to very recent times. He instanced places near Wellington where he had collected very many moa-bones and egg-shells. At one of these spots he had found "gallons" of the egg-shells, which had plainly been cooked, and the contents of which had doubtless been eaten. To his mind the evidence was overwhelming that the moa was here a hundred years ago. He gave reasons for believing that moa-eggs (some of them in process of incubation) had been eaten in abundance by the Natives in different parts of the colony.

2. "Feeding-place of Starlings," by Henry M. Christie.

3. "Some New Compounds of a Similar Nature to Antifebrine," by P. W. Robertson, M.A., Rhodes Scholar. (*Transactions*, p. 45.)

Professor Easterfield pointed out that the work embodied in Mr. Robertson's paper could claim, in addition to its scientific interest, a direct utilitarian value.

4. "Experiments in Telepathy," by J. W. Poynton.

It was moved by Dr. A. K. Newman, and seconded by Mr. Edward Tregear, "That, this being the last meeting of the Society which Mr. P. W. Robertson will attend prior to his departure for Oxford, the meeting extends to him its congratulations on his securing a Rhodes scholarship, and offers him its best wishes for success in his future career."

The motion was carried by acclamation.

Mr. Robertson thanked the meeting heartily for its motion of good will, and expressed his acknowledgments to the Society for its action in allowing him to publish in the Transactions the results of his work.

Exhibits.—Miss Mestayer exhibited: (1) A specimen of carborundum; (2) a specimen of *Scutum ambiguum*; (3) specimens of several other shells.

Popular Lecture: *19th July*, 1905.

Mr. Martin Chapman, President, in the chair.

A popular lecture on "The Indians of the Far Canadian North" was given by Dr. J. M. Bell, Director of the New Zealand Geological Survey.

The lecture was open to the public, and a very large number of persons attended.

Dr. Bell illustrated his lecture by an interesting series of lantern-slides from photographs taken by himself in Canada.

On the motion of Mr. G. Hogben, seconded by Mr. Edward Tregear, a vote of thanks was passed to Dr. Bell for his lecture.

Fourth Meeting: *2nd August*, 1905.

Mr. Martin Chapman, President, in the chair.

New Members.—Dr. Arnold W. Izard and Messrs. James McDonald, T. R. Fleming, Ernest F. Hadfield, and W. J. Harland.

An advance copy of Vol. XXXVII (1904) of the "Transactions and Proceedings of the New Zealand Institute" was laid on the table.

Exhibit. — Dr. A. K. Newman exhibited a Maori war-trumpet.

At the invitation of the Chairman, Mr. W. H. Warren played on the instrument a number of army regulation bugle-calls. He explained that most of the army calls could be given on this trumpet.

Mr. Edward Tregear said that the trumpet was used in former times by the Natives for signalling in a sort of telegraphic code, as well as for war purposes.

Papers. — 1. "A Rare Image of the Maori God of Eels (Tuna)," by Dr. A. K. Newman. (*Transactions*, *p.* 130.)

The author exhibited the image described in the paper.

2. "Notes on Insect Swarms on Mountain-tops in New Zealand," by G. V. Hudson, F.E.S. (*Transactions*, p. 334.)

3. "Notes on a Meteoric Appearance," by Martin Chapman. (*Transactions*, p. 143.)

4. "Note on the Facultative Saprophytism of *Alternaria solani*," by A. H. Cockayne.

5. "On some *Foraminifera* and *Ostracoda* obtained off Great Barrier Island, New Zealand," by Frederick Chapman, A.L.S., F.R.M.S., Palæontologist National History Museum, Melbourne; communicated by A. Hamilton. (*Transactions*, p. 77.)

Mr. T. W. Kirk, F.L.S., Government Biologist, by invitation addressed the meeting on "Potato and Tomato Diseases" and on "Nitrogen-fixing Bacteria," illustrating his remarks by a number of exhibits.

A hope was expressed that Mr. Kirk would renew the subjects at a subsequent meeting, and give members an opportunity of discussing them more fully than was possible in the limited time available on this occasion.

Mr. Kirk promised to do so.

Fifth Meeting: *6th September*, 1905.

Mr. Martin Chapman, President, in the chair.

New Members.—Mr. J. S. Tennant and Mr. Thomas William Downes (Wanganui).

Mr. T. W. Kirk continued his remarks (adjourned from the previous meeting) on "Potato and Tomato Diseases" and on "Nitrogen-fixing Bacteria."

In illustration of the points touched upon, he threw upon the screen a number of lantern photographs. He strongly insisted upon the economic importance of the subjects.

A number of questions were asked by members, and duly answered by Mr. Kirk.

A vote of thanks was passed to Mr. Kirk for bringing these questions before the Society.

Paper.—"On Temporary Stars," by Martin Chapman. (*Transactions*, p. 139.)

Exhibits.—1. Mr. G. Hogben exhibited and described seismograms taken at Wellington and Tokyo of the great Indian earthquake of the 4th April, 1905.

2. Mr. Martin Chapman exhibited a specimen of Maori chewing-gum.

He said that this substance was found on most parts of the coast of the North Island, and also at the Chatham Islands. The specimen in question had been given to him by a Chatham Island Native. The Maoris were rather fond of chewing this substance, much in the same way as white children were addicted to chewing indiarubber. The Natives called it *mimiha*, meaning the hair seal; or *pakake*, signifying whale; also *waka-atua*, "canoe of demons." They said that its common form resembled that of a canoe. Mr. Chapman said that to him the substance appeared to be crude petroleum, completely sun-dried—*i.e.*, the volatile parts had evaporated, leaving only the heavy or pitch-like residue.

Sixth Meeting: *4th October*, 1905.

Mr. Martin Chapman, President, in the chair.

New Members.—Mr. and Mrs. Joseph A. Tripe, and Messrs. G. A. Hurley, J. M. A. Ilott, and C. B. Morison.

The Chairman announced that an extra meeting of the Society would be held on the 1st November, and that a popular lantern lecture on "New Zealand Birds" would probably be given at the beginning of December by Mr. Edgar F. Stead, of Christchurch.

Papers.—1. "Maori Place-names, with Special Reference to the Great Lakes and Mountains of the South Island," by James Cowan. (*Transactions*, p. 113.)

Mr. Justice Chapman, referring to the list of place-names mentioned by Mr. Cowan as having been compiled by himself (Mr. Justice Chapman), said that in listening to the paper he had been struck by the fact that the results obtained by Mr. Cowan from personal investigations amongst the Natives showed almost absolute agreement with those obtained by himself, although he had derived his information from people living a hundred and fifty miles away from the Maoris consulted by Mr. Cowan. It was rather surprising that two independent inquirers should come to such agreement in work of the sort. It was very difficult to get information about these place-names from authentic Maori sources, although easy enough to obtain so-called information from Natives possessing no real claims to knowledge. He agreed with Mr. Cowan in thinking that the majority of Native place-names were personal names. He complimented Mr. Cowan upon the accuracy of his work.

2. "Ruas on Seatoun Heights," by H. N. McLeod.

3. "On *Flabellum rugulosum*," by Henry Suter, Auckland; communicated by A. Hamilton. (*Transactions*, p. 334.)

4. "Notes on New Zealand *Mollusca*, with Descriptions of New Species and Sub-species," by Henry Suter, Auckland; communicated by A. Hamilton. (*Transactions*, p. 316.)

Annual Meeting: *4th October*, 1905.

Mr. Martin Chapman, President, in the chair.

The Council's annual report and annual statement of receipts and expenditure were read and adopted.

The report mentioned (*inter alia*) that six meetings had been held during the session of 1905, and that twenty-one papers in all had been read.

The attendance at most of the meetings had been good.

Two members had resigned, and seventeen new members had been elected. The total number of members now on the roll was 110; but this was likely to be reduced somewhat, as the roll was about to undergo further revision, several nominal members being in arrears with their subscriptions.

In recognition of his invaluable services to science and to the Society, Sir James Hector, K.C.M.G., had been elected an honorary life-member of the Society.

The statement of receipts and expenditure showed that the receipts (including a balance of £44 9s. 7d. brought forward from the previous financial period) amounted to £106 8s. 7d., and the expenditure to £70 4s. 6d., leaving a credit balance of £36 4s. 1d., which, with the sum of £41 3s. at credit of the Research Fund with the Bank of New Zealand, made a total of £77 7s. 1d. in hand.

The previous annual meeting having been held in April, 1905, the period covered by the present statement was one of only some six months: but, these six months being the months of session, the expenditure was relatively heavier than the receipts. The present meeting had been called in October, instead of in the following autumn, because of an alteration in the rules of the New Zealand Institute. Under one of the new rules of the Institute it was necessary that matter intended for insertion in any given year's volume of the Transactions and Proceedings should be in the hands of the editor of that publication not later than the 31st December of such year. This made it desirable to hold the annual meeting at some convenient time towards the end of the session, and no doubt future Councils, following the precedent set on the present occasion, would arrange their dates accordingly each year.

Election of Officers for 1906.—*President*—Mr. Martin Chapman; *Vice-Presidents*—Professor T. H. Easterfield and Mr. G. V. Hudson; *Council*—Professor H. B. Kirk, Mr. C. E. Adams, B.Sc., Sir James Hector, K.C.M.G., F.R.S., Dr. A. K. Newman, Mr. J. W. Poynton, Mr. A. Hamilton, and Mr. T. W. Kirk, F.L.S.; *Secretary and Treasurer*—Mr. Thomas King; *Auditor*—Mr. E. R. Dymock, A.I.A., N.Z.

Seventh Meeting: 1*st November*, 1905.

Mr. Martin Chapman, President, in the chair.

New Member.—Mr. Henry Rix-Trott.

The Chairman said that it was his sad duty to announce the death of Captain F. W. Hutton, F.R.S., of Christchurch, President of the New Zealand Institute.

He said that Captain Hutton was very widely known by reason of his scientific work, and the loss which the colony sustained by his death was a very great one. Captain Hutton was a man of the highest scientific attainments, and one whose work was of great value to New Zealand.

On the motion of the Chairman, seconded by Professor T. H. Easterfield, the following resolution was unanimously passed: "The Council and members of the Wellington Philosophical Society desire to place on record their sincere regret at the death of Captain F. W. Hutton, F.R.S., President of the New Zealand Institute, and their high appreciation of his work in almost every branch of natural history; and they direct that a copy of this resolution be sent to Mrs. Hutton."

Papers.—1. "Notes on some South Island Birds and Maori Associations in connection therewith," by James Cowan. (*Transactions*, p. 337.)

Captain Gilbert Mair complimented Mr. Cowan on his paper. As to the shining cuckoo (pipiwharauroa), Captain Mair pointed out that although, so far as the South Island was concerned, Mr. Cowan might be correct in saying that the bird did not appear until October, it was a mistake to think that the real time of its arrival in the colony was as late as this. As a matter of fact, in some parts of the North Island this yearly visitor appeared about the 21st September. Captain Mair's father, who lived in the Auckland Province from 1818 onwards, used regularly to hear the bird's cry on or about that date.

2. "The Transformation of Barley into Malt," by Percy B. Phipson.

With the aid of drawings on the blackboard, and of specimens of the grain, Mr. Phipson gave an explanation of the process of obtaining malt from barley. The exhibits showed the various stages through which the grain passed before it was finally converted into malt.

Professor T. H. Easterfield and Professor H. B. Kirk spoke highly of the extreme clearness with which Mr. Phipson had set forth a subject which was not always treated very satisfactorily in the text-books.

3. "Some Historic Maori Personages," by Thomas W. Downes, Wanganui. (*Transactions*, p. 120.)

In the discussion on this paper, Captain Gilbert Mair said that he considered that a painting of Te Rauparaha which was executed by the late Mr. C. D. Barraud, of Wellington, in 1845 was the best portrait in existence of that warrior.

Mr. Hamilton pointed out that the value of Mr. Downes's communication lay in the fact that he had enjoyed the privilege of access to the sketch-books of the late Mr. Gilfillan. As Mr. Downes's photographs had been produced entirely without handwork or retouching of any kind they were to be relied upon as accurate copies of the original sketches.

4. "Tram-line and Railway Curves," by Miss Maud Rigg, M.A., Jacob Joseph Scholar in the Victoria College, Wellington; communicated by Professor R. C. Maclaurin.

Popular Lecture: *6th December*, 1905.

Mr. Martin Chapman, President, in the chair.

A lantern lecture on "New Zealand Birds" was delivered by Mr. Edgar F. Stead, of Christchurch.

The lecture was open to members and their friends, admission (to avoid overcrowding) being by ticket. A full audience was present.

A large and extremely interesting series of photographs of birds and their nests, from negatives taken from life by Mr. Stead, was shown on the screen, each picture being briefly described by the lecturer.

On the motion of Professor T. H. Easterfield, seconded by Professor H. B. Kirk, a hearty vote of thanks was passed to Mr. Stead.

AUCKLAND INSTITUTE.

First Meeting: *5th June*, 1905.

Professor A. P. W. Thomas, President, in the chair.

New Members.—W. S. Douglas, W. J. Hazard, E. Langguth.

The President delivered the anniversary address, taking as his subject "Nitrogen-fixing Bacteria."

The address was copiously illustrated with lantern-slides and diagrams, and specimens of plants grown with and without the aid of nitrogen-fixing bacteria were exhibited.

At the conclusion of the address a cordial vote of thanks was passed to Professor Thomas.

Second Meeting: *3rd July*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Mr. E. Clarke, M.A., gave a popular lecture, with numerous limelight illustrations, on "Rivers and their Work."

Third Meeting: *31st July*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Professor F. D. Brown delivered a popular lecture, illustrated with numerous experiments, on "Alcohol as a Fuel."

Fourth Meeting: *28th August*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Professor C. W. Egerton gave a popular lecture on "Thackeray."

Fifth Meeting: *25th September*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Mr. J. H. Howell, B.Sc., gave a popular lecture, with numerous experiments, entitled "The Story of Radium."

Sixth Meeting: *9th October*, 1905.

Professor A. P. W. Thomas, President, in the chair.

New Members.—E. C. Brown, G. M. Newton.

Papers.—1. "Description of a New Grass," by D. Petrie, M.A. (*Transactions*, p. 423.)

2. "The Winged Pilot of Hawaiki," by Archdeacon P. Walsh. (*Transactions*, p. 127.)

3. "A Find of Kauri-gum at Rangitikei, Wellington," by S. A. R. Mair. (*Transactions*, p. 499.)

4. "Notes on the Growth of certain Native Trees in the Auckland Domain," by J. Stewart, C.E. (*Transactions*, p. 374.)

5. "The Scenery and Rocks of the Omahu Coast," by H. G. Cousins, M.A.

SEVENTH MEETING: *23rd October*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Professor H. W. Segar delivered a popular lecture, copiously illustrated with limelight views, on "The Sun."

EIGHTH MEETING: *6th December*, 1905.

Professor A. P. W. Thomas, President, in the chair.

Papers.—1. "The *Whare Potae*, or House of Mourning," by Elsdon Best. (*Transactions*, p. 148.)

2. "Additions to the New Zealand Fauna," by Rev. W. Webster. (*Transactions*, p. 309.)

3. "Results of Dredging on the Continental Shelf of New Zealand," by Rev. W. Webster. (*Transactions*, p. 305.)

NINTH MEETING: *26th February*, 1906.

Professor A. P. W. Thomas, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

Five new members had been elected during the year, a number considerably below the average. On the other hand, twelve names had been withdrawn from the roll. There had thus been a net decrease of seven, the total number of members at the present time being 153.

The report referred with regret to the death of Mr. L. D. Nathan, who had been connected with the Institute for more than twenty-five years, and who had always been a liberal supporter of its interests.

The Council also expressed their regret at the decease of Captain F. W. Hutton, the President of the New Zealand Institute, who had been a most active and zealous supporter of the Institute from the time of its formation in 1868. In conjunction with the late Mr. Justice Gillies he materially aided in the formation of the Auckland branch of the Institute.

The gross total revenue of the Working Account had been £1,232 5s. 1d. Deducting from this sum two exceptional items of £150 received on account of the Mackechnie bequest for the purchase of groups of large animals, and £100, an advance from the Investment Account towards defraying the cost of erecting the Maori house, the ordinary revenue had been £982 5s. 1d., being an increase of £24 3s. on the receipts for the previous year. The invested funds of the Costley bequest had yielded £342 1s. 3d., as against £371 19s. for the previous year. The Museum endowment, in rents and interest, contributed £351 9s. 11d., an increase of £11 4s. 1d. on the amount for 1904–5. £134 10s. 6d. had been transferred from the Mackechnie Library Bequest Account for the purchase of books, and £117 12s. had been derived from members' subscriptions. The total expenditure had been £1,174 1s. 5d., which included the two exceptional items of £127 14s. 10d. paid on account of groups of mammals, and £115 1s. 9d. for the erection of the Maori house. The credit balance at the Bank of New Zealand at present was £58 3s. 8d. The Council had no change to report with respect to the invested funds of the Institute, the total amount of which (£16,263 1s. 8d.) was the same as last year.

With the exception of a short period devoted to cleaning and rearrangement, the Museum had been open daily to the public during the year. The attendance of visitors had been most satisfactory, and was the largest yet recorded. On Sunday afternoons 20,440 visitors entered the building, being an average of 393 for each Sunday. The greatest attendance was 618, on the 11th June; the smallest 157, on the 27th October. On the seven principal holidays the number of visitors was 2,583, or an average of 369. On ordinary week-days it is believed that the average daily attendance was 125, making a total of 38,252 for week-days, or of 61,275 for the whole year. Last year the attendance was estimated at 46,285. The number of visitors during the three hours the Museum is open on Sunday was quite half the total attendance for the remainder of the week.

Fair progress has been made with the erection of the new Maori house. The elaborately carved sideposts had all been set up, and the framework of the roof completed, the rafters having been painted by Maoris from old designs kindly lent by Mr. C. E. Nelson. A large supply of kakaho, or reeds, had been obtained for the lining of the roof, and many other preparations made. But for the unfortunate destruction of the reed-work panels by fire at Rotorua, where they were being prepared, the house would have been well advanced towards completion. The Council trust, however, that it may yet be finished before the coming winter.

The second group of large stuffed animals provided by the Mackechnie bequest had been received during the year and placed on exhibition. The third group, consisting of a polar bear and three musk oxen (male, female, and young), was now on its way from England, and would arrive in a few weeks. A fourth group was being prepared, and would probably arrive before the end of the year. The two groups at present exhibited attract considerable attention.

The increased revenue now derived by the library from the special bequest of £2,000 made by the late Mrs. Mackechnie had enabled the Council to order three consignments of books from their London agent.

The question of additional accommodation for the library urgently required consideration.

The Council desired to convey the thanks of the Institute to the numerous donors to the Museum and library. They also wish to tender the special thanks of the Society to the Tyser Steamship Company and the New Zealand Shipping Company for the free carriage of the groups of mammals obtained from the Mackechnie bequest. The thanks of the Institute were also due to Mr. C. E. Nelson for supervising the construction of various carvings and other material required for the completion of the Maori house, and for much valuable advice connected therewith.

Election of Officers for 1906.—*President* — Professor F. D. Brown; *Vice-Presidents*—Professor A. P. W. Thomas and Dr. E. Roberton; *Council*—L. J. Bagnall, H. Haines, J. Kirker, E. V. Miller, T. Peacock, D. Petrie, J. A. Poul, J. Reid, Professor H. W. Segar, J. Stewart, J. H. Upton; *Trustees*—T. Peacock, J. H. Upton, Professor F. D. Brown; *Secretary and Curator*—T. F. Cheeseman, F.L.S.; *Auditor*—W. Gorrie.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

First Meeting: *3rd May*, 1905.

Dr. Farr, President, in the chair.

Dr. Chilton reported that he and Captain Hutton had attended the last meeting of the Board of Governors of the New Zealand Institute, and that Captain Hutton, F.R.S., had been elected President of the Institute for the current year.

Dr. Chilton then delivered his ex-presidential address on "Mimicry in Nature."

Second Meeting: *7th June*, 1905.

Mr. R. Speight, Vice-President, in the chair.

New Members.—Dr. W. Malcolm Thomson, Dr. A. C. Sandstein, Major Snow, Mr. F. Hitchings, Mr. J. S. Jamieson, Mr. C. P. Powell, Mr. F. Clark, Mr. E. Kidson, Mr. G. Hurst Seager, and Mr. C. A. Seager.

Address.—Mr. R. Nairn gave an address on "Autumn Colouring of Leaves."

Papers.—1. "Note on a Water-beetle found in Sea-water," by Dr. Chilton. (*Transactions*, p. 63.)

2. "Note on the Occurrence of *Metoponorthus pruinosus* in New Zealand," by Dr. Chilton. (*Transactions*, p. 64.)

3. "On a Skeleton of *Emeus crassus* from the North Island," by Captain Hutton, F.R.S.; communicated by Dr. Chilton. (*Transactions*, p. 66.)

4. "On *Crassatellites trailli*," by Captain Hutton, F.R.S.; communicated by Dr. Chilton. (*Transactions*, p. 65.)

5. "Notes on the *Hemiptera* of the 'Index Faunæ-Novæ-Zealandiæ,'" by Mr. G. W. Kirkaldy; communicated by Dr. Chilton. (*Transactions*, p. 61.)

6. "The Combustion of Methane in the Presence of Palladium-Asbestos," by Mr. H. G. Denham. (*Transactions*, p. 39.)

7. "The Technical Analysis of Coal and Coal-testing," by Mr. A. M. Wright. (*Transactions*, p. 42.)

THIRD MEETING: *5th July*, 1905.

Dr. Farr, President, in the chair.

New Members.—Mrs. Carey Hill, Mr. R. English, Mr. F. E. Allen, Mr. C. K. Meredith-Kaye, Mr. J. Allen Mitchell, and Mr. P. L. Hallenstein.

Address.—Mr. E. G. Hogg, M.A., delivered an address on "Planetary Atmospheres."

Papers.—1. "Notes on a Brief Botanical Visit to the Poor Knights Islands," by Dr. Cockayne; communicated by Dr. Chilton. (*Transactions*, p. 351.)

2. "The Leaf Anatomy of some Characteristic Plants of the Southern Islands of New Zealand," by Miss Herriott, M.A.; communicated by Dr. Chilton. (*Transactions*, p. 377.)

3. "Appendix to the List of Seaweeds of Norfolk Island," by R. M. Laing, M.A., B.Sc. (*Transactions*, p. 424.)

SPECIAL MEETING: *28th July*, 1905.

Dr. Farr, President, in the chair.

Address.—Professor Rutherford, F.R.S., delivered an address on "Radium and its Transformations," illustrated by numerous experiments, before a crowded meeting of the Institute in Canterbury College Hall.

A vote of thanks to Professor Rutherford was proposed by Professor Easterfield, Victoria College, and seconded by Professor Evans, Canterbury College.

FOURTH MEETING: *2nd August*, 1905.

Dr. Farr, President, in the chair.

New Members.—Dr. Diamond, Mr. G. W. Hulme, Mr. E. Phillips Turner.

Address.—Professor Scott gave an address on "The Resistance of Steel to Mechanical Shock, and the Determination of Material suitable for Machinery." (*Transactions*, p. 515.)

Fifth Meeting: *6th September*, 1905.

Dr. Farr, President, in the chair.

New Members.—Dr. Alice Moorhouse, Mr. W. Smith, and Mr. J. Bevan Brown.

Address.—Mr. E. F. Stead gave an address, illustrated by numerous lantern-slides, on "Bird Life in New Zealand."

Papers.—1. "On a Specific Case of Leaf-variation in *Coprosma baueri*, Endl. (*Rubiaceæ*)," by Dr. Cockayne. (*Transactions*, p. 341.)

2. "On the Supposed Mount Bonpland Habitat of *Celmisia lindsayi*, Hook. f.," by Dr. Cockayne. (*Transactions*, p. 346.)

3. "On the Common Tangents of Two Conics," by Mr. E. G. Hogg, M.A.; communicated by Dr. Farr.

4. "Notes on Thermo-chemistry," by Mr. S. Page.

Sixth Meeting: *4th October*, 1905.

Dr. Farr, President, in the chair.

New Members.—Mr. Molyneux and Mr. W. R. B. Oliver.

Address.—Mr. F. Hitchings gave an address, illustrated by numerous charts, on "Sun-spots."

Paper.—"The Distribution of the *Rotifera* in New Zealand," by F. W. Hilgendorf, D.Sc.

Seventh Meeting: *1st November*, 1905.

Dr. Farr, President, in the chair.

The President referred to the great loss sustained by the Institute in the death of Captain Hutton, F.R.S.

He moved the following resolution: "That the Philosophical Institute of Canterbury learns with profound regret the death of Captain F. W. Hutton, F.R.S., President of the New Zealand Institute, and desires to place on record its high appreciation of the many valuable services he has rendered to science, and its sense of the great loss caused by his death. Captain Hutton joined the Institute rather more than twenty-five years ago; he served almost continuously as a member of the Council, and on several occasions as Honorary Treasurer and President, and contributed in a very large degree to the growth and prosperity of the Institute, and at various times he rendered similar valuable services to the Otago Institute, the New Zealand Institute, the Australasian Association for the Advancement of Science, and other scientific bodies. By his long series of original contributions on the geology and zoology of New Zealand he established the knowledge of these subjects on a sure and permanent foundation, and made for himself a world-wide reputation as a geologist and zoologist, and by his researches on the origin of the fauna and flora of New Zealand he became a recognised authority on questions of bio-geography. In the various offices he held in connection with the Geological Survey of New Zealand, the Otago University and Museum, and Canterbury College and Museum, he faithfully and most efficiently discharged duties of great value to the colony, and has left an example worthy of imitation by all. That in offering to Mrs. Hutton and her family sincerest sympathy in their bereavement, the Institute trusts that they will derive some consolation from the fact that Captain Hutton has not lived and laboured in vain, and that the loss of his mature judgment and wide knowledge of New Zealand science will be felt not only by the whole colony, but by scientific men throughout the world."

It was seconded by Dr. Chilton, and spoken to by Mr. Laing, Mr. Mayne, Dr. Cockayne, Mr. Marriner, Mr. Speight, and Mr. Watkins.

The motion was carried in silence, all present standing.

The meeting then adjourned for one week.

Eighth Meeting: *8th November*, 1905.

Dr. Farr, President, in the chair.

New Member.—Mr. E. Bartley.

Address.—Dr. F. W. Hilgendorf gave an address entitled "A Discussion of the Theories of the Formation of the Canterbury Plains and of the Influence of the Earth's Rotation on the Courses of the Canterbury Rivers."

The address was illustrated by means of a model of the lower Waimakariri Gorge, and by numerous diagrams of transverse sections of various Canterbury Rivers.

Annual Meeting: *6th December*, 1905.

Dr. Farr, President, in the chair.

New Members.—Mr. A. C. Bowbyes, Mr. W. Wigley, Mr. P. McCallum.

Papers.—1. "On the *Musci* of New Zealand, with Descriptions of New Species (Genus *Macromitrium*)," by Mr. R. Brown.

2. "Report on some *Crustacea* dredged off the Coast of Auckland," by Dr. Chilton. (*Transactions*, p. 265.)

3. "List of *Crustacea* from the Chatham Islands," by Dr. Chilton. (*Transactions*, p. 269.)

4. "Description of a Species of *Phreatoicus* from the Surface Waters of New Zealand," by Dr. Chilton. (*Transactions*, p. 274.)

5. "Note on the Occurrence in New Zealand of Dipterous Insects belonging to the Family *Blepharoceridæ*," by Dr. Chilton. (*Transactions*, p. 277.)

6. "Notes on the Sub-alpine Scrub of Mount Fyffe (Seaward Kaikouras)," by Dr. Cockayne. (*Transactions*, p. 361.)

7. "On Introduced Birds," by Mr. J. Drummond.

8. "A Theorem connecting Surface and Volume Integrals," by Mr. E. G. Hogg, M.A.

9. "On Steiner's Quartic Surface," by Mr. E. G. Hogg, M.A.

10. "On the Anatomy of *Hyla aurea*," by Mr. G. R. Marriner. (*Transactions*, p. 257.)

Annual Report of Council.

The Council has met eight times since the last annual meeting of the Institute, and the average attendance of the members of the Council at such meetings has been eight.

The Council has to deplore the great loss it has sustained by the death of Captain Hutton, F.R.S. Owing to his absence from the colony, Captain Hutton's services were at the disposal of the Council for only a part of the year, but during the period he was able to attend the meetings his wide knowledge and mature judgment were—as for many years previously—of the geatest assistance to the Council in its conduct of the business of the Institute. The Council desires to place on record its high appreciation of the services rendered by Captain Hutton to science in New Zealand, and to the Philosophical Institute of Canterbury in particular.

The scientific event of the greatest interest during the year was the visit of Professor Rutherford, F.R.S. The Institute co-operated with Canterbury College in welcoming him to Christchurch at a conversazione held in the College hall on the 24th July, and on the evening of Friday, the 28th July, Professor Rutherford delivered, under the auspices of the Institute, in the same hall, a lecture on "Radium and its Transformations," which attracted a crowded audience.

During the year the Council has been in correspondence with the Government and other branches of the New Zealand Institute on the subject of the preservation of the native fauna and flora of the outlying islands of New Zealand, with special reference to the Campbell and Auckland Groups. The result of the correspondence has not been satisfactory, but the Council trusts that the matter may be revived at some future time, and certain islands be set apart as preserves for the native fauna and flora.

Large additions have been made during the year to the library in different branches of science, and the scientific journals taken by the Institute have been increased in number. The Council is of opinion that the members of the Institute do not by any means take full advantage of the really valuable scientific library which is at their disposal.

During the year twenty-eight new members of the Institute have been elected, and the total membership is now 124, including five life members. The average attendance at the meetings has been fifty. Seven addresses have been given, and twenty-four papers have been read. The latter may be classified as follows: Botany, 7; chemistry, 3; mathematics, 3; zoology, 11. The Council considers the large number of original papers read during the year as gratifying evidence of the vitality of the Institute.

The balance-sheet shows that after paying £41 19s. 10d. for new books, and transferring £50 to a fixed deposit, there remains a credit balance of £29 16s. 7d.

The thanks of the Council are due to the Board of Governors of Canterbury College for the use of rooms, and to Mr. G. E. Way for his continued services as Honorary Auditor.

Dr. Chilton and Dr. Farr were elected as representatives of the Institute on the Board of Governors of the New Zealand Institute.

The following resolutions, relative to the formation of a Research Fund in memory of the late Captain Hutton, F.R.S., were unanimously adopted :—

1. That it is desirable that in memory of Captain F. W. Hutton a fund be established to be known as the "Hutton Memorial Research Fund."

2. That the fund be devoted to the encouragement of original research in natural science in New Zealand.

3. That the fund when established be vested in and controlled by the Board of Governors of the New Zealand Institute.

4. That it be suggested to the Board of Governors of the New Zealand Institute that, in addition to making grants from time to time to persons engaged in original research, a bronze medal be struck, to be called the "Hutton Medal," and be awarded at suitable intervals to persons who have made original contributions of special value to the natural science of New Zealand.

5. That in order to save time the Philosophical Institute of Canterbury commence the collection of subscriptions for the purposes above mentioned, with the view of afterwards handing them over to the New Zealand Institute, and that a contribution of £50 from the funds of the Philosophical Institute be made to the fund.

Election of Officers for 1906.—*President*—Mr. R. Speight; *Vice-Presidents*—Dr. C. C. Farr, Dr. F. W. Hilgendorf; *Hon. Secretary*—Mr. E. G. Hogg; *Hon. Treasurer*—Dr. Chilton; *Council*—Dr. Cockayne, Mr. H. G. Denham, Dr. Evans, Mr. R. M. Laing, Mr. J. B. Mayne, Mr. C. J. Williams; *Hon. Auditor*—Mr. G. Way, F.I.A., N.Z.

OTAGO INSTITUTE.

FIRST MEETING: *9th May*, 1905.

The President, Mr. J. C. Thomson, in the chair.

New Members.—Professor J. Malcolm, Dr. Riley, Messrs. E. J. Parr, W. Downie Stewart, Robert Browne, and J. Blair Mason.

The President delivered his presidential address on "The Resources of New Zealand" (fully reported in the *Otago Daily Times*, 10th May).

He dealt, firstly, with agricultural and pastoral callings, tracing out the developmental history of the frozen-meat trade and the export of butter. In regard to flax, he pointed out the great need for experimental work in the direction of treating the fibre and producing the sort of material familiar to Maoris; he insisted on the suicidal policy pursued by flaxmillers in destroying the flax over large areas, and making no provision for propagation of the best varieties. The fruit industry and fishing industry both needed systematic study; in the latter, the desirability of utilising waste products, for the extraction of oil and manufacture of manure, was referred to. Passing on to the mineral resources, he gave statistics with regard to gold, silver, coal, iron-ore, antimony, scheelite, copper, &c., as well as of limestone, phosphate rock, and cement. He pointed out the value of our timber-supply, and the need for Government to interfere in order to obviate the waste caused by annual clearings of bush land. The excellent work carried on by the Forestry Department was discussed; and finally, reference was made to the valuable resource that New Zealand has in its water-supply, both for irrigation purposes and for power.

At the conclusion of his remarks he was, on the motion of Dr. Hocken, seconded by Mr. E. Herbert, accorded a hearty vote of thanks for his very instructive practical address.

Mr. G. M. Thomson made some remarks upon a specimen of mistletoe growing on a hawthorn, submitted by the Hon. Secretary (Mr. Robert Gilkison).

He pointed out that mistletoes usually put their radicles into the heart of the trees upon which they grew and sucked the unassimilated sap, while dodders sucked the formed sap from the outside. This specimen showed both types of nutrition.

SECOND MEETING: *13th June*, 1905.

Mr. J. C. Thomson, President, in the chair.

Exhibits.—Professor Benham exhibited and made remarks upon a cast of the skull of an early ancestral horse (*Mesohippus*) recently acquired by the Museum, and compared it with the skull of a recent horse; and gave a brief account of the evolution of the horse.

Mr. G. M. Thomson, local Secretary of the Australasian Association for the Advancement of Science, laid upon the table an advance copy of the report of the Dunedin meeting.

Mr. Thomson gave some account of the work being carried on at the Marine Fish-hatchery at Portobello.

A short note by Mr. H. P. Young, of Orepuki, was read, "On the Native Name of the Fuchsia."

In the Maori name for fuchsia (*kotukutuku*) the *tukutuku* signifies that the flowers are pendulous. The name seems to have been the exclamation of one Native to another on first seeing a number of these flowers: "*Kotukutuku!*" ("They all hang down"). Another name, *konini*, appears to be derived from *ninia*, to glow, and may be applied on account of the glossy, shining appearance of the flower. According to Mr. Cheeseman this name is applied to the fruit; but Mr. Young's informant—an intelligent North Island Native—says it is the common name in the Taranaki district for the flowering plant.

Mr. D. B. Waters delivered a short lecture on "Oil Engines."

Mr. W. D. Stewart gave a brief account of a trip across Siberia, illustrated by lantern-slides.

Third Meeting: *20th July*, 1905.

Mr. J. C. Thomson, President, in the chair.

Professor Easterfield delivered a most interesting lecture, illustrated by experiments, on "The Romance of Coal-tar."

A vote of thanks, moved by Professor Black and seconded by Mr. G. M. Thomson, was carried with acclamation.

Fourth Meeting: *8th August*, 1905.

Mr. J. C. Thomson, President, in the chair.

Papers.—1. "Notes on the Distribution of Ores in Horizontal Zones in Vertical Depth," by Professor Park.

2. "On the Geology of the Clarendon Phosphate-deposits," by Arthur Robert Andrew, B.Sc., A.O.S.M.; communicated by Professor James Park; with map. (*Transactions*, p. 447.)

3. "Notes on the Influence of Country Rock in Relation to the Distribution of Valuable Contents of Lodes, with Special

Reference to the Productive Zones in the Thames Goldfields, New Zealand," by Professor Park; with plans and section.

4. "Notes on the Formation of Zones of Secondary Enrichment in certain Metalliferous Lodes," by Professor Park.

5. "Notes on the Origin of the Metal-bearing Solution concerned in the Formation of Ore-deposits," by Professor Park.

6. "On the Occurrence of Gold at Harbour Cone," by C. N. Boult, B.Sc.; communicated by Dr. P. Marshall; with maps. (*Transactions*, p. 425.)

Addresses by Professor Benham and Mr. G. M. Thomson on "Modern Work on Evolution" were delivered.

Dr. Benham dealt chiefly with some of the modern factors of evolution, such as mutation, isolation, and the experimental study of variation.

Mr. Thomson discussed certain modern work on heredity, especially "mendelism."

FIFTH MEETING: *12th September*, 1905.

Mr. J. C. Thomson, President, in the chair.

New Member.—Mr. J. W. Henton.

Dr. Hocken, referring to a proposal to introduce English owls into New Zealand, stated that these birds preyed on mice, voles, &c., and only rarely attacked small birds.

Mr. F. W. Payne gave a lecture on "Irrigation in Central Otago."

Papers.—1. "Entomology in Southland," by G. Howes, F.E.S.

2. "Some New Species of *Lepidoptera*," by G. Howes, F.E.S. (*Transactions*, p. 510.)

SIXTH MEETING: *17th October*, 1905.

Mr. J. C. Thomson, President, in the chair.

Exhibits.—Dr. Marshall exhibited some fossil ferns from the Hokonui Hills, near Gore, some of which belonged to the Jurassic period, and others of an earlier geological time.

Some of these showed fructification on the fronds, and indicated a genus found in New Zealand at the present day. Others were of a kind not now found here.

Dr. Marshall exhibited some polished bowenite—a kind of transparent greenstone much more rare than the greenstone commonly found in the colony.

Dr. Benham exhibited casts of the skull and feet of the generalised fossil mammal *Phenacodus.*

The changes that had gradually taken place in the form of the foot of the horse, from those found on the fossil remains of the horse to that of the present time, were explained by means of the casts and skeleton legs exhibited.

Dr. Benham also exhibited the peculiar spiral cases of the caddis-worm *Helicopsyche*, received per Mr. R. Browne, of Tokanui.

Dr. Malcolm exhibited a capillary electrometer, and explained its action by means of sketches on the blackboard. Afterwards, under a microscope, by means of the instrument, the electric current in living tissues was shown in a frog's muscle.

Papers.—1. "An Account of some Earthworms from Little Barrier Island," by Dr. Benham. (*Transactions*, p. 248.)

2. "Some Additional Earthworms from the North Island," by Dr. Benham. (*Transactions*, p. 239.)

3. "Note on a Large Specimen of *Pterotrachea*," by Dr. Benham. (*Transactions*, p. 245.)

Dr. Hocken began the reading of a very interesting paper on "The Rev. Samuel Marsden and the Early New Zealand Missions."

The author has collected a mass of very valuable data relating to his subject, and during his recent visit to England gathered much authentic infoımation in the village near Leeds where Mr. Marsden was born. The paper dealt with the early life, the education at the university, the ordination, and the appointment to an official position in New South Wales of the reverend gentleman; but the biographical sketch had not got beyond the voyage out to Botany Bay in the convict ship "William," and the birth of a daughter in the midst of very rough shipboard surroundings, when the further reading of the paper was adjourned.

Seventh Meeting: *14th November*, 1905.

Mr. J. C. Thomson, President, in the chair.

The following resolution was passed: "That the members of the Otago Institute record their great sense of the loss which the cause of biological science has sustained by the death of Captain Hutton, F.R.S. As an indefatigable and earnest worker in many branches of natural science he has left his mark deep on the scientific records of this colony, in which his name will always be remembered as one of the pioneers of biological work. As teacher of biology and geology in Otago University and Canterbury College, as Curator of both Museums, as President of this Institute and of the New Zealand Institute, and as President of the Australasian Association for the Advancement of

Science, he did yeoman's service for the cause which he had so much at heart. That a copy of this resolution be forwarded to Mrs. Hutton, together with an expression of the Institute's deep sympathy with her and with the members of her family in their bereavement."

The above was moved by Mr. G. M. Thomson, seconded by Dr. Hocken, and Drs. Benham and Marshall spoke to the motion.

Professor Benham exhibited a probably extinct species of wren (*Traversia lyalli*) obtained on Stephen Island, and a species of gigantic weta (*Hemideina broughi*) from the West Coast.

Papers.—1. "Treatment of Partially Decomposed Pyritic Tailings by the Cyanide Process," by Mr. F. Shepherd; communicated by Professor Park. (*Transactions*, p. 558.)

2. "Portobello Fish-hatchery, with Scientific Notes and Record of Observations," by Mr. G. M. Thomson, F.L.S. (*Transactions*, p. 529.)

3. "The Gem Gravels of Kakanui, with Remarks on the Geology of the District," by Mr. J. Allan Thomson, B.Sc., Rhodes Scholar. (*Transactions*, p. 482.)

4. "Geological Notes on the West Coast," by Dr. Marshall. (*Transactions*, p. 560.)

5. "Note on the Occurrence of Two Rare and Two Introduced Moths," by Mr. G. Howes. (*Transactions*, p. 509.)

Mr. G. Howes read the following note on "Fruit-destruction by Small Birds in Central Otago":—

I have lately returned from a trip through Central Otago, and while in the Teviot and Alexandra districts had my attention called to a new phase in the destruction of fruit by small birds. Until this year fruit has been comparatively safe until it ripened. Now they are attacking the trees while still in flower and just as the fruit forms. Roxburgh and Coal Creek have over thirty orchards producing fruit for the market. Of these half a dozen only have escaped serious loss from the ravages of small birds. Some orchards have only one-tenth of their usual crops left. The smaller outlying orchards have been practically stripped, the larger ones adjoining each other not having suffered so heavily. The birds, of whom the green linnet seems the worst offender, attacked the apricots after the fruit was formed, and the cherries while still in flower. When I left they were attacking the peaches and plums also. I visited the two largest orchards at Alexandra, and they have suffered greatly. Mr. Iverson will be a very heavy loser, having some 20 acres of fruit-trees, and yet only able to save the fruit on trees immediately about his house. The introduction of owls has been advocated, and if they are to be introduced there could be no better districts than the Teviot and Alexandra for the experiment. There are but few native birds for the owl to destroy, and the hill-sides swarm with destructive introduced birds.

Dr. Hocken read the second part of his instructive paper on "The Rev. Samuel Marsden and Early New Zealand Missions."

Dr. Hocken sketched in a most interesting manner the terribly uphill and disheartening work of a missionary in the early days of the convict establishment in New South Wales.

Annual Meeting.

The annual meeting was then held.

The annual report stated, *inter alia*, that during the session ten new members were elected and ten had resigned, the total membership standing at 102.

A very handsome gift was made to the Institute by Dr. Fulton of a fine collection of New Zealand birds' eggs, which were gratefully accepted and handed over to the Otago University Museum.

The Council, on the strength of information received from various members, drew the attention of the Government to matters of pressing importance in connection with the preservation of our fauna and flora, and had assurances from the Government that the recommendations will be favourably considered. It is hoped that prompt action will be taken.

Referring to the lecture by Professor Easterfield, delivered in the chemistry room at the University, the report states that it is matter for regret that the attendance of members was small, and it is certainly neither encouraging to the lecturer nor to the Council in securing talent from beyond our own borders.

The Chairman moved the adoption of the report.

He said that it was an interesting fact that several of the papers contributed were written by students of Otago University. He hoped that their example would be followed. He referred also to the fact that the membership of the Institute never seemed to get much beyond about a hundred. The balance-sheet showed a revenue of £170. When they commenced the year they had a balance of £25 10s. 2d., and at the end of the year the balance was £52 5s. 5d. According to their rules they were supposed to spend at least a third of their revenue on literature. This year they had spent over half.

The report and balance-sheet were formally adopted.

Election of Officers for 1906.—*President*—Dr. P. Marshall; *Vice-Presidents*—Mr. J. C. Thomson and Dr. Fulton; *Hon. Secretary*—Professor Benham; *Hon. Treasurer*—Mr. W. Fels; *Council*—Mr. A. Bathgate, Dr. Hocken, Mr. G. M. Thomson, Mr. E. Collier, Professor Malcolm, Professor Park, and Mr. D. B. Waters.

It was recommended that Dr. Benham and Mr. G. M. Thomson should be elected in December Governors of the New Zealand Institute.

Dr. Marshall having returned thanks for his election, the meeting terminated.

WESTLAND INSTITUTE.

Abstract of Annual Report.

The total revenue of the General Account, not including the balance brought forward at the beginning of the year and £70 transferred from the Special Account, has been £86 1s. 10d. The total expenditure was £149 9s. 4d.

About sixty volumes have been purchased during the year.

The reading-room is well supplied with the leading daily and the local papers, the latter being donated to the room. The Institute desires to record its thanks to the proprietors for these, also to the Government for publications sent from the Government Printing Office.

Mr. Henry Weston, who for seventeen years acted as Secretary and Librarian, found it necessary, owing to old age and failing health, to resign his position, and Mr. C. Kirk was appointed in his place. The Trustees desire to thank Mr. J. B. Ward for his kind assistance during the last few months of Mr. Weston's service.

The most important circumstance during the year was the obtaining of the grant of £2,000 from Mr. Carnegie for a new library. The plan for this building has been sent to Mr. Carnegie for his approval, and we may look forward to seeing the completion of the institution in the course of twelve months.

Election of Officers for 1906.—*President*—Mr. H. L. Michel; *Vice-President* — Mr. G. A. Perry; *Treasurer* — Dr. Macandrew; *Trustees*—Messrs. Beare, Clarke, Dunne, Heinz, Lewis, McNaughton, Morton, Park, Wake, Wilson, and Mabin; *Auditors*—Messrs. Foley and Ward.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Annual Report.

During the session seven ordinary and four Council meetings have been held. At the ordinary meetings five lectures were delivered and four papers read. One of the most enjoyable meetings was that devoted to the microscope. Lecturettes were delivered dealing with the structure of the microscope, the preparation of slides, and photomicrography. and a great many specimens were exhibited, no fewer than fourteen microscopes being brought into use.

The Colenso botanical specimens have been placed on deposit in the Colonial Museum, where they will be in safe keeping, and will be available for scientific purposes.

Hoping to widen the scope of the Institute's usefulness, your Council placed the library at the disposal of the teachers of the district as a reference library. They regret to report, however, that, although only a nominal subscription was asked, advantage has not been taken of the offer in the manner that was anticipated, only two teachers having availed themselves of the opportunity.

Mr. Hill's term of office as this branch's representative on the Board of Governors of the New Zealand Institute having expired, the Council again elected him to that position.

Your Council regret that Mr. W. H. Antill, Vice-President, who has for some years taken an active interest in the work of the branch, has found it necessary to resign membership on account of his removal from the district. Two new members have been elected during the year.

Nine new volumes have been added to the Society's library.

The Treasurer's balance-sheet shows a small credit balance.

Papers and Lectures read before the Institute during the Session 1905.

2nd May.—The President, H. Hill, B.A., F.G.S., delivered the inaugural address, his subject being "Social and Industrial Questions as they affect New Zealand."

6th June.—Paper by J. Guthrie-Smith, "The Native Birds of Three Hawke's Bay Runs."

4th July.—Lecture by Dr. Kennedy, "Meteorological Instruments and how to use them."

1st August.—Papers: (1.) H. Hill, B.A., F.G.S., "Wanted, a Colonial Scientific Advisory Board." (2.) W. Dinwiddie, "National Character."

5th September.—Lecturettes: (1.) Dr. Leahy, "The Construction of the Microscope." (2.) Dr. Henley, "The Preparation of Slides." (3.) Dr. Kennedy, "Photomicrography." By means of fourteen microscopes a large number of interesting specimens were exhibited.

3rd October.—Paper by Dr. Leahy, "Electric Currents of High Frequency."

Election of Officers for 1906.—*President*—W. Dinwiddie; *Vice-President*—E. A. W. Henley, M.B.; *Council*—J. Guthrie-Smith, T. Hall, H. Hill, B.A., F.G.S., J. P. Leahy, M.B., D.P.H., T. C. Moore, M.D., T. Tanner; *Hon. Secretary*—Jas. Hislop, District School; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White; *Lanternist*—C. F. Pointon.

NELSON INSTITUTE.

Abstract of Annual Report.

During the year a considerable amount of work was done in the direction of reorganizing the Museum. Several new cases were purchased, and different members undertook the cataloguing and arranging of various classes of exhibits. A great improvement had been effected, and there is no doubt that during the coming year the work would have been carried to a successful issue, had not the recent calamitous fire undone all that had been achieved. Fortunately, not many of the exhibits were actually destroyed or lost, but many were seriously damaged.

The thanks of the Institute are due to Messrs. Charles and Lionel Mackie, who kindly lent to the Museum a choice collection of minerals and curios. Fortunately, these were little injured in the fire.

In November, Dr. Bell, the Director of the New Zealand Geological Survey, kindly gave, under the auspices of the Scientific Branch, an interesting lecture on his experiences in the far north of Canada. The net proceeds, which amounted to over £10, were devoted to the Museum fund.

A number of meetings were held during the winter months for the discussion of scientific subjects, and were well attended. Mr. Worley gave an account of the geology of the City of Nelson and its neighbourhood, and illustrated his remarks with maps, diagrams, and specimens. Dr. Hudson delivered a lecture on the subject of Nelson weather, and exhibited in diagrammatic form the results of observations which he had made over a period of many years. Mr. Gibbs gave a lecture on electricity and X rays, and showed experiments with a powerful Wimshurst machine and a Rontgen ray apparatus. Short papers were read on the brilliant June meteor, the various potato-blights, and some insect pests, and several other subjects and numerous exhibits were shown at the meetings and discussed. The Scientific Branch will no doubt continue to meet during the coming winter, and all persons who take an interest in scientific matters are cordially invited to attend.

MANAWATU PHILOSOPHICAL SOCIETY.

First Meeting: *23rd February*, 1905.

Mr. Kenneth Wilson, M.A., President, in the chair.

Mr. P. E. Baldwin read an exhaustive paper on the "Early Native Records of the Manawatu Block."

He traced the migration of the tribes, hapus, and families of the Maoris; their wars, victories, and final occupation of the land from the Manawatu Gorge to the Oroua River.

Several members took part in the discussion which followed.

Second Meeting: *16th March*, 1905.

Mr. Sinclair, in the absence of the President, in the chair.

Mr. William Welch read a paper on "Etchings and Steel Engravings."

He gave an account of the growth and final decay of these arts, and exhibited a large number of samples of, and explained the processes of, wood engravings, line, dry-point, silver-point, mezzotint, aquatint etching on steel and copper.

Third Meeting: *18th May*, 1905.

The President, Mr. Kenneth Wilson, M.A., in the chair.

New Members.—Alex. Paterson, M.D., and Captain Hewitt, R.N.

Dr. Stowe read a paper on "Radium and the X Rays," which was illustrated by a powerful battery, in which he showed the development of electroms.

Mr. C. E. Warden read a paper on "Education," in which he dealt with the methods of the primary schools, and advanced theories for the improvement of our present system.

This meeting was thrown open to the public.

Fourth Meeting: *15th June*, 1905.

The President, Mr. Kenneth Wilson, M.A., in the chair.

New Member.—Mr. W. F. Durward.

Dr. Paterson read a paper on "The Subjective Ego: its Nature and Manifestations, its Influence on the Moral, Mental, and Physical Conditions of Man."

A discussion among the members followed, after which Dr. Paterson replied.

This meeting was thrown open to the public.

Fifth Meeting: *6th July*, 1905.

The President, Mr. Kenneth Wilson, M.A., in the chair.

Professor Easterfield, M.D., of Wellington, delivered a lecture on "Poisons," which he illustrated by numerous experiments.

The ground covered comprised: (*a*) Poisons from a historical standpoint; (*b*) classification of poisons; (*c*) the detection of those poisons commonly used for criminal purposes; and (*d*) the poisonous constituents of some New Zealand poisons.

A discussion followed, during which many questions were asked by members, and replied to by the Professor.

This meeting was also thrown open to the public.

Annual Meeting: *20th July*, 1905.

The President, Mr. Kenneth Wilson, M.A., in the chair.

The report and balance-sheet were read and approved.

In the former it was shown that the Society had been eminently successful in its first year of work. It now numbered thirty-nine members, and eleven papers were read. The Palmerston North Borough Council had placed a room at the disposal of the Society for a museum, and from the number of specimens, curios, &c., that had been promised, the museum bade fair to become a success.

The New Zealand Institute presented the Society with thirty-two volumes of its Transactions, which had been bound and placed in the library.

The balance-sheet showed a credit of £13.

Election of Officers for 1906. — *President* — John E. Vernon, M.A.; *Vice-Presidents*—Kenneth Wilson, M.A., P. E. Baldwin, Dr. Stowe; *Council*—W. Collingwood, M. A. Eliott, F. Goote, B.A., G. Hirsch, W. H. Maclean, A. A. Martin, M.D. *Secretary and Treasurer*—William Welch; *Curator of the Museum*—William Welch; *Auditor*—R. N. Keeling.

SEVENTH MEETING: *24th August*, 1905.

Mr. Kenneth Wilson, M.A., in the chair.

Mr. D. W. Low read a paper on "Idealism and Realism in Art."

EIGHTH MEETING: *28th September*, 1905.

The President, Mr. John E. Vernon, M.A., in the chair.

New Members.—Mr. J. H. Hankins, and Mrs. Mellsopp, M.A.

The Rev. I. Jolly, M.A., read a paper on "Some Recent Discoveries in Babylon, and the Laws of the Great King Huma-Rabi," before a very large audience, in the Opera House.

NINTH MEETING: *19th October*, 1905.

The President, Mr. John E. Vernon, M.A., in the chair.

Dr. Martin read a paper on "Fatigue and Sleep," in the Opera House, before a crowded audience.

He dealt with the action on the brain-cells of physical and mental fatigue, and the recovery by rest and sleep.

The paper was illustrated by numerous diagrams.

TENTH MEETING: *23rd November*, 1905

The President, Mr. John E. Vernon, M.A., in the chair.

Mr. H. Drew read a paper on "A Record of the Enderby Settlement in the Auckland Islands in 1850."

This paper was made specially interesting by the fact that the author was a lineal descendant of one of the officers of that expedition, and that he had gleaned his information at first hand.

APPENDIX

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

Finsch, Otto, Ph.D., of Bremen, Leiden, Holland.

Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., Royal Gardens, Kew.

1873.

Günther, A., M.D., M.A., Ph.D., F.R.S., Litchfield Road, Kew Gardens, Surrey.

1874.

Newton, Alfred, F.R.S., Magdalen College, Cambridge, England.

1875.

Sclater, Philip Lutley, M.A., Ph.D., F.R.S., Zoological Society, London.

1876.

Berggren, Dr. S., Lund, Sweden.

1877.

Sharp, Dr. D., University Museum, Cambridge.

1883.

Lord Kelvin, P.C., G.C.V.O., D.C.L., F.R.S., 13, Eaton Place, S.W.

Ellery, Robert L. J., F.R.S., Observatory, Melbourne.

1885.

Sharp, Richard Bowdler, M.A., F.L.S., Zoological Museum, Cambridge.

Wallace, A. R., F.L.S., Broadstone, Wimborne, England.

1890.

Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden.

Liversidge, Professor A., M.A., F.R.S., Sydney.

1891.

Goodale, Professor G. L., M.D., LL.D., Harvard University, Massachusetts, U.S.A.

1894.

Dyer, Sir W. T. Thiselton, K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Royal Gardens, Kew.

Codrington, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

1895.

Mitten, William, F.L.S., care of Linnean Society, London.

1896.

Lydekker, Richard, B.A., F.R.S., British Museum, South Kensington.

1900.

Agardh, Dr. J. G., University of Lund, Sweden.

Avebury, Lord, P.C., F.R.S., High Elms, Farnborough, Kent.

Massee, George, F.L.S., F.R.M.S.

1901.

Eve, H. W., M.A., 37, Gordon Square, London.

Goebel, Dr. Carl, University of Munich.

1902.

Sars, Professor G. O., University of Christiania, Norway.

1903.

Klotz, Professor Otto J., 437, Albert Street, Ottawa, Canada.

1904.

Rutherford, Professor E., McGill University, Canada.

David, Professor T. Edgeworth, Sydney University, N.S.W.

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Bell, H. D.
Bell, Dr. J. M.
Blair, J. R.
Brandon, A. de B.
Browne, M. H.
Buller, Sir Walter L., K.C.M.G., D.Sc., F.R.S.
Campbell, J. P.
Chalmers, A. B.
Chapman, Martin
Christie, Henry M.
Christie, Mrs. Henry M.
Chudleigh, E. R.
Clarke, A. T.
Cockayne, A.
Cockayne, Dr. L.
Cowan, J.
Cowper, D. A. S.
Denton, George
Downes, Thomas William, Wanganui
Dymock, E. R.
Easterfield, Prof., M.A., Ph.D.
Ewen, Charles A.
Ferguson, W., M.Inst.C.E.
Field, H. C., Wanganui
Fitzgerald, G., A.M.Inst.C.E.

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Fletcher, Rev. H. J., Taupo
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Hanify, H. P.
Harding, R. Coupland
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McWilliam, Rev. J., Otaki
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Reid, W. S.
Richardson, C. T.
Rix-Trott, Henry
Robinson, W. F., Masterton
Roy, R. B., New Plymouth*
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Skerman, Dr. Sidney, Marton
Smith, Charles, Wanganui
Stewart, J. T., Wanganui
Tennant, J. S.
Travers, H. H.
Tregear, E.
Tripe, Joseph A.
Tripe, Mrs. Mary E.
Turnbull, A. H.
Turnbull, R. T.
Turnbull, Thomas
Waley, A. S., London
Wallis, Rt. Rev. Dr. Frederic, Bishop of Wellington
Wilton, G. W.
Woodhouse, Alfred James, London

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Cooper, Mr. Justice, Wellington.
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Barningham, J.
Batchelor, F. C., M.D., M.R.C.S.
Bathgate, Alexander*
Bell, A. D., Shag Valley
Benham, Professor W. B., D.Sc., M.A., F.Z.S.
Black, Alexander
Black, Professor J. G., D.Sc.
Blair, John, Mornington
Bowman, John
Brent, Daniel, M.A.*
Brown, William
Browne, Robert, Stratford
Buchanan, N. L.*
Burnside, John A.
Campbell, Robert, St. Clair
Carew, W. S.
Chamberlain, C. W.
Chapman, C. R.
Chapman, Mr. Justice
Chisholm, Robert
Clarke, Edgar S.
Collier, E. E.
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De Beer, Isidore S.
Don, J. R., D.Sc., M.A., Waitaki
Duncan, Peter
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Payne, Fred. Wm.
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Reid, George
Richardson, Charles R. D., M.A.
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Ritchie, J. M.
Roberts, John, C.M.G.
Roberts, W. S., M.R.C.S.
Russell, George Gray
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Sargood, Percy R.
Scott, Prof. J. H., M.D.
Shacklock, John B.
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Smith, J. Crosby, Invercargill
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Stewart, W. Downie
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Thomson, J. C.
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Clarke, J. J.
Cook, Miss
Cook, Mrs.
Dabinett, J. L.
Douglas, Rev. W.

Dowell, B.
Duncan, W.
Dunne, J. P.
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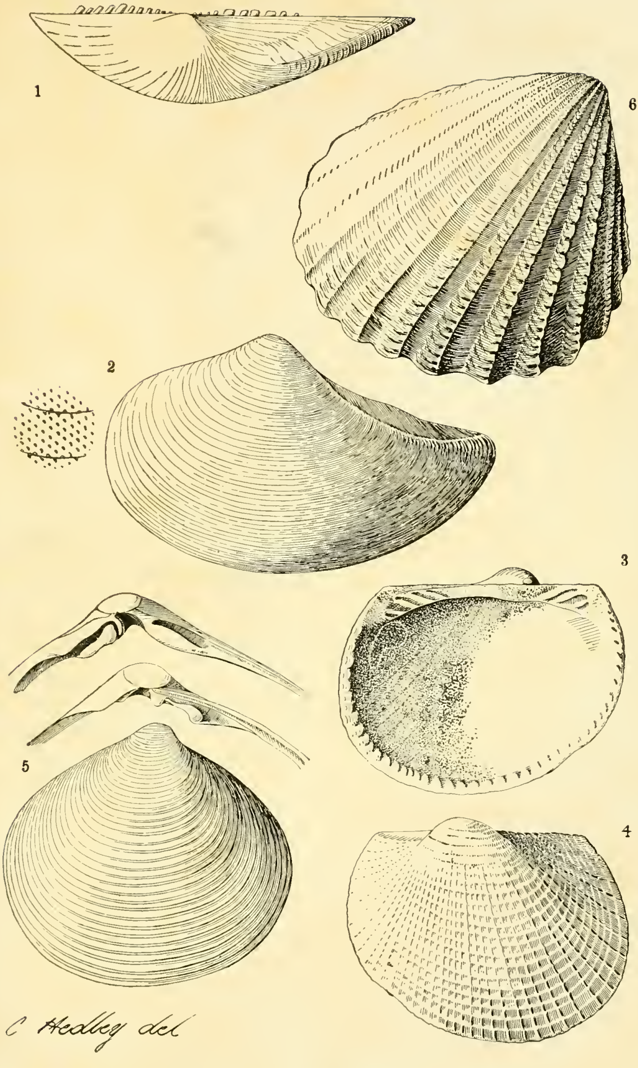

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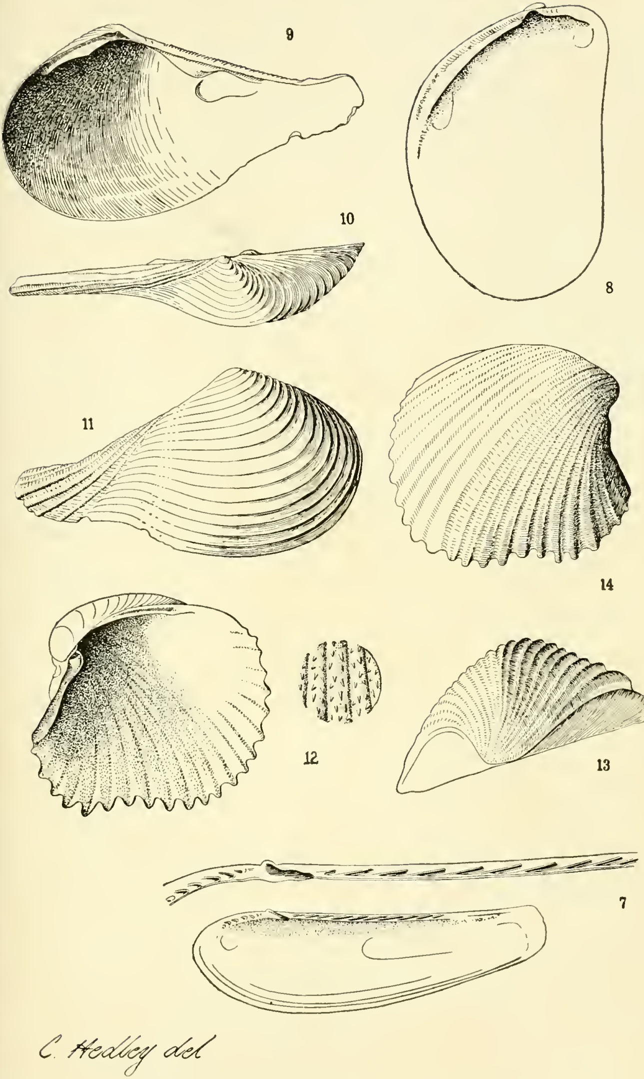

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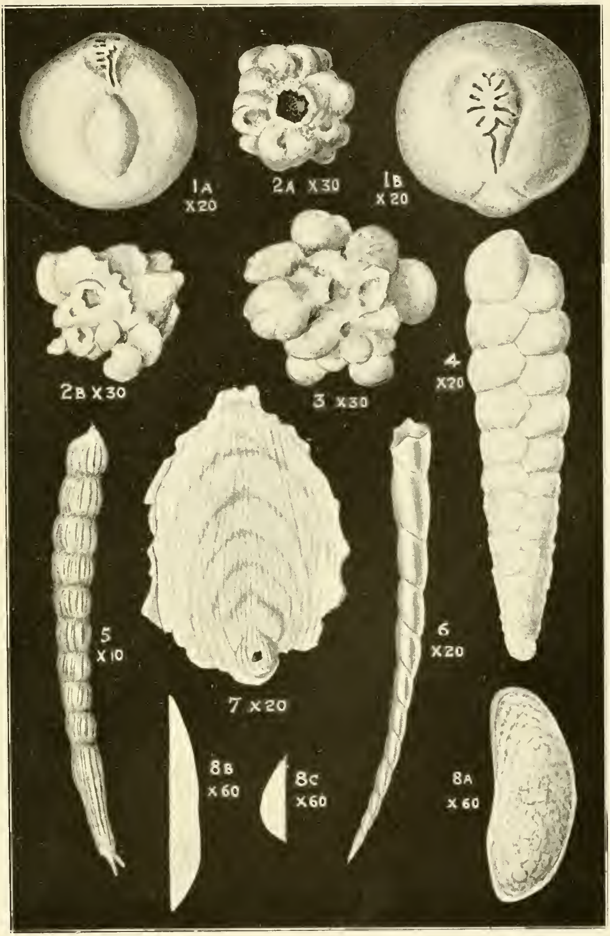

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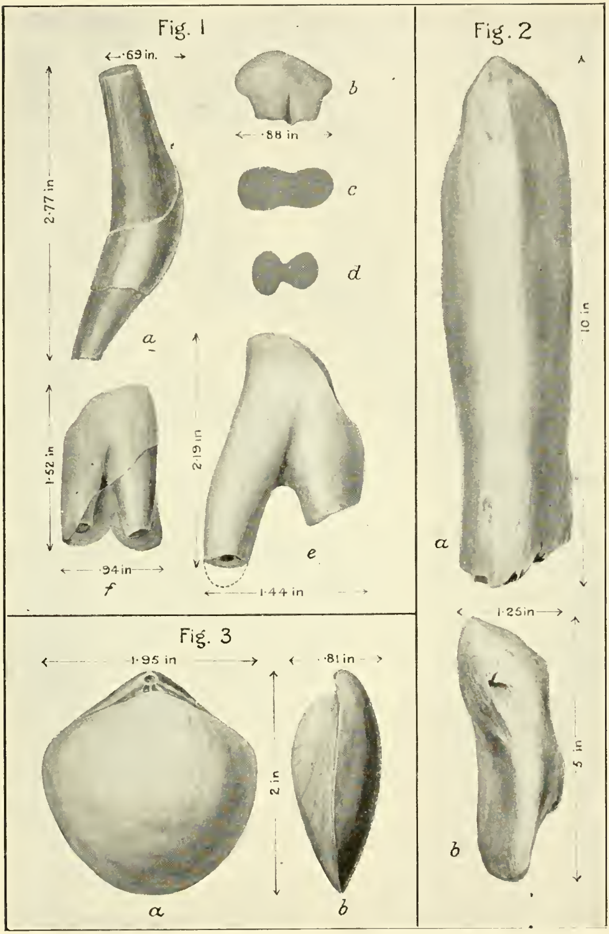

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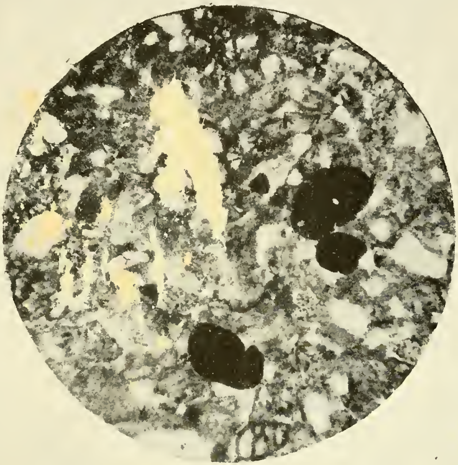

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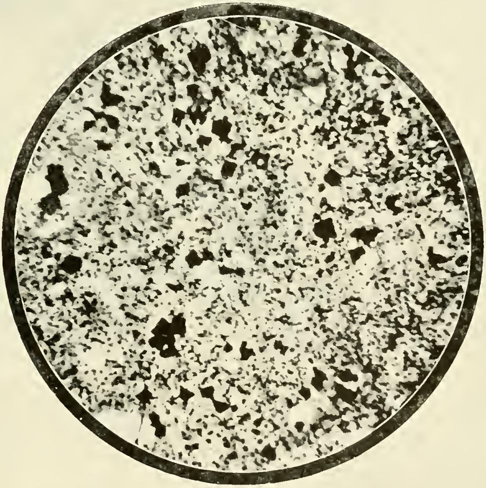

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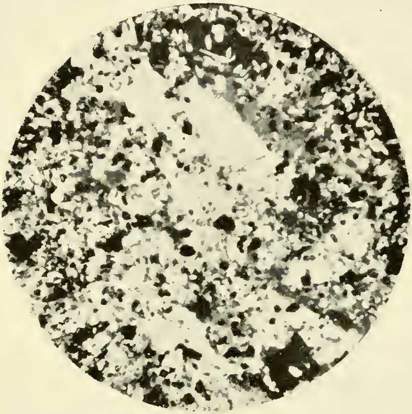

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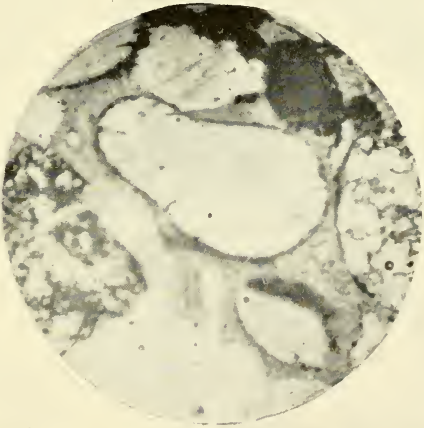

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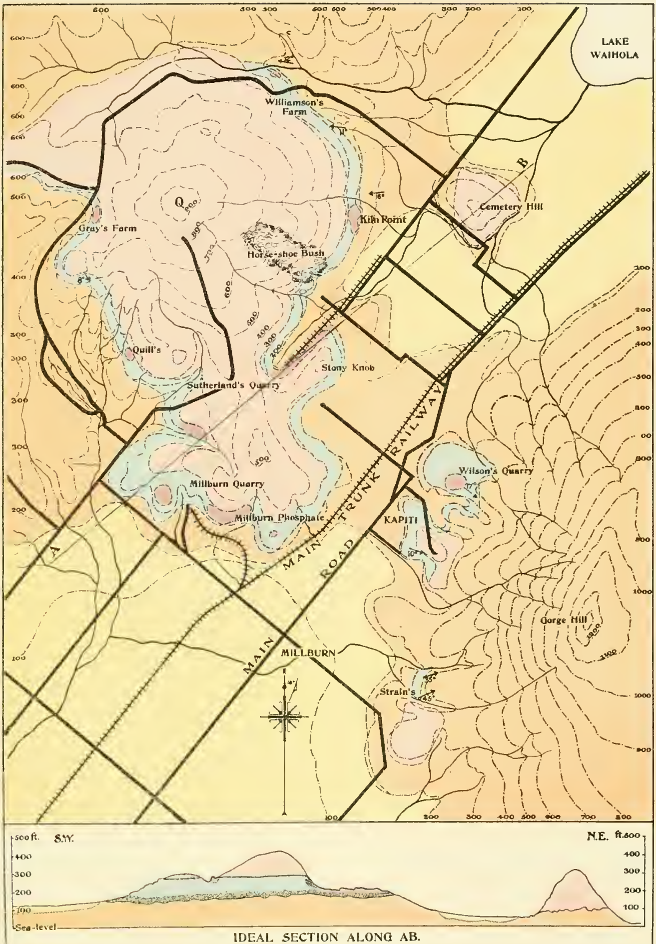

GEOLOGICAL MAP OF CLARENDON-MILLBURN DISTRICT.

Pliocene	Alluvium	
Lower Tertiary	Basalt	
Lower Tertiary	Sandstone	
„ „	Phosphate	
Lower Tertiary	Limestone	
„ „	Glauconite sands	
	Mica schist	

Scale.

0 ½ 1 1½ 2 MILES.

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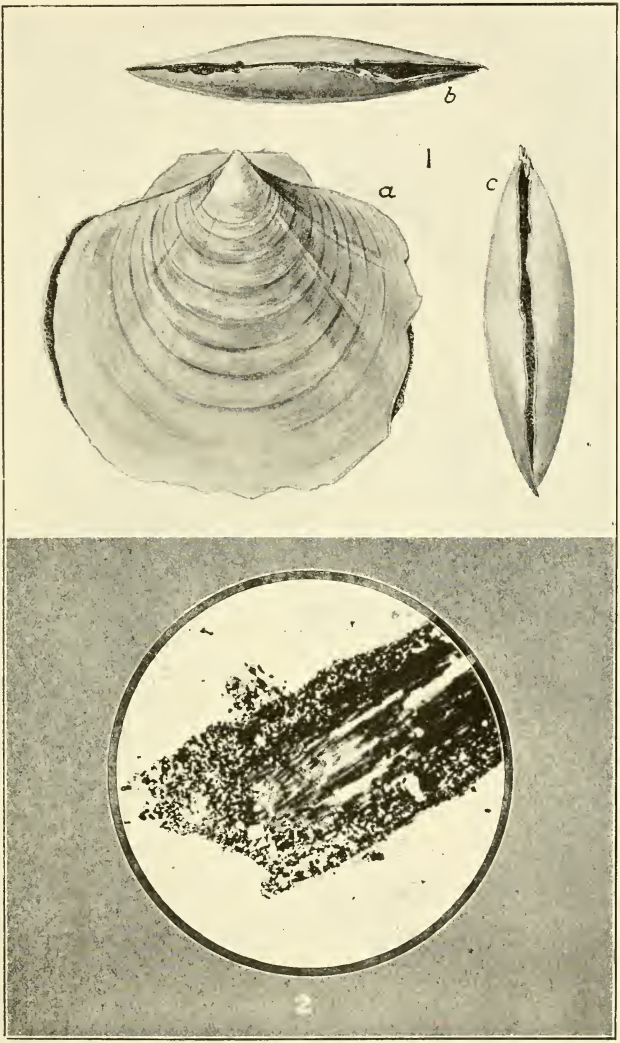

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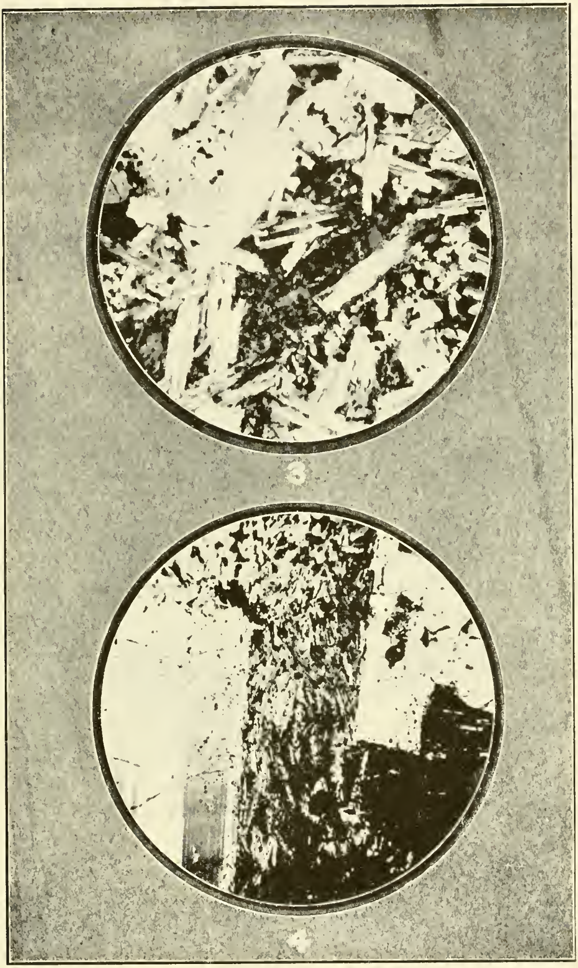

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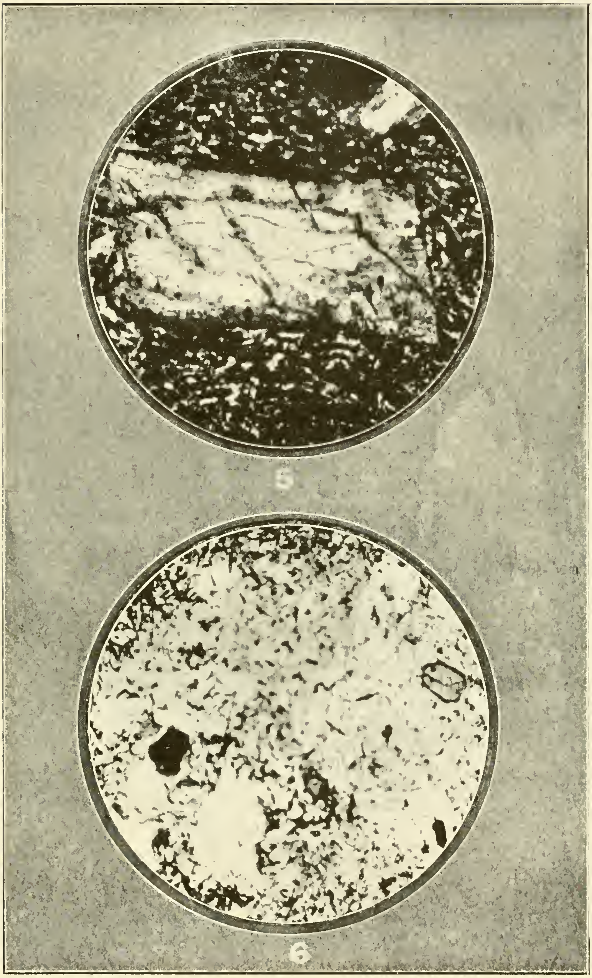

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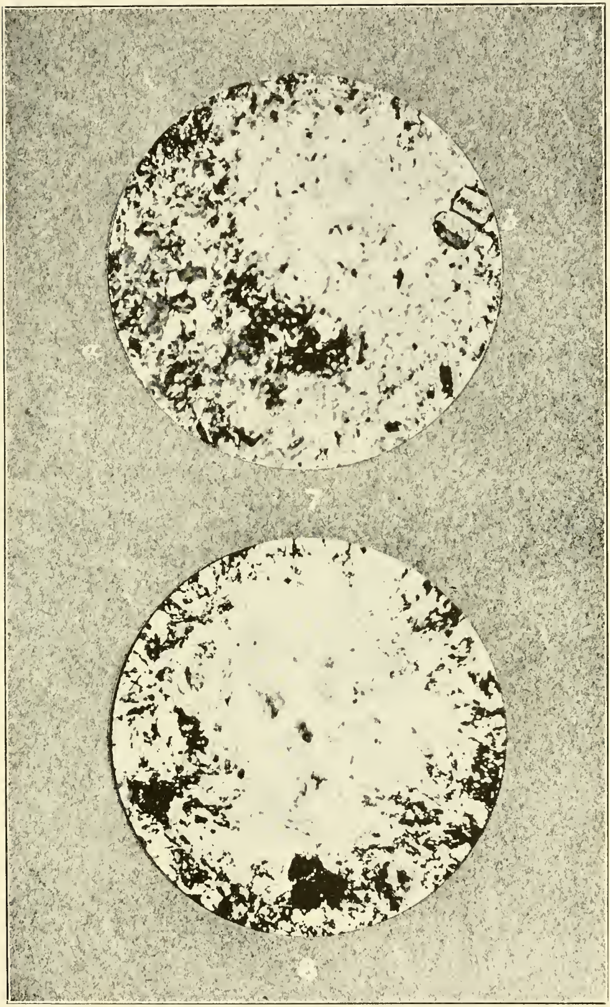

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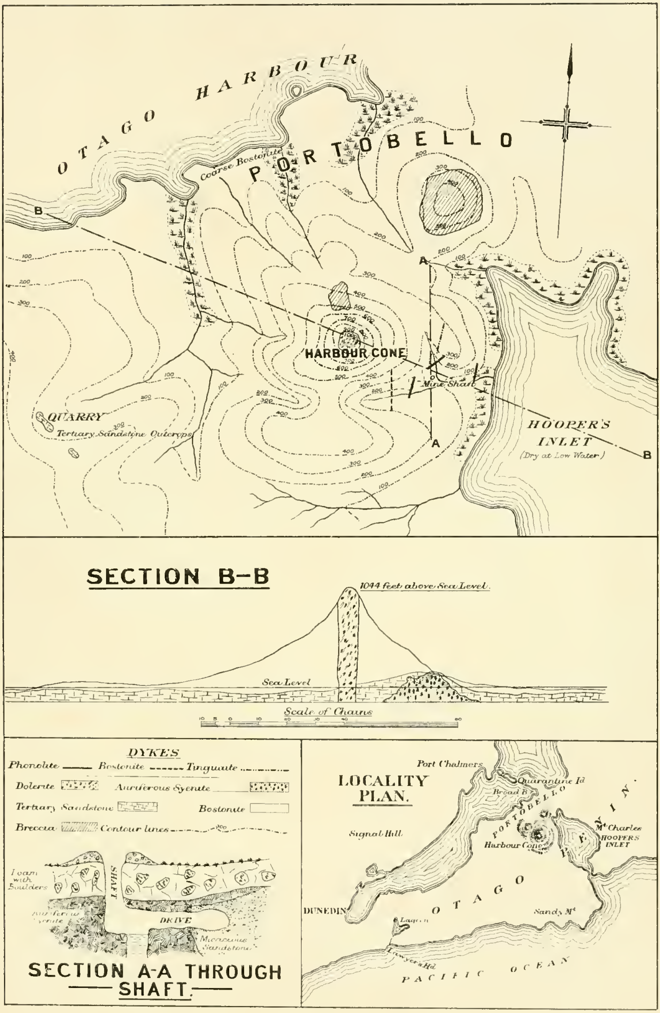

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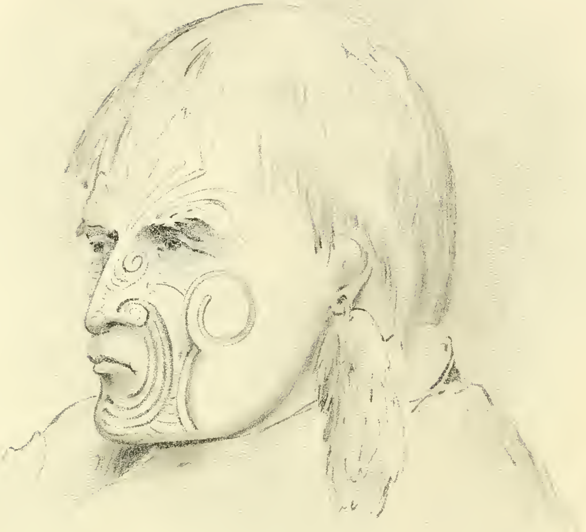

Rauparaha

Te Rauparaha.

Hone Heke

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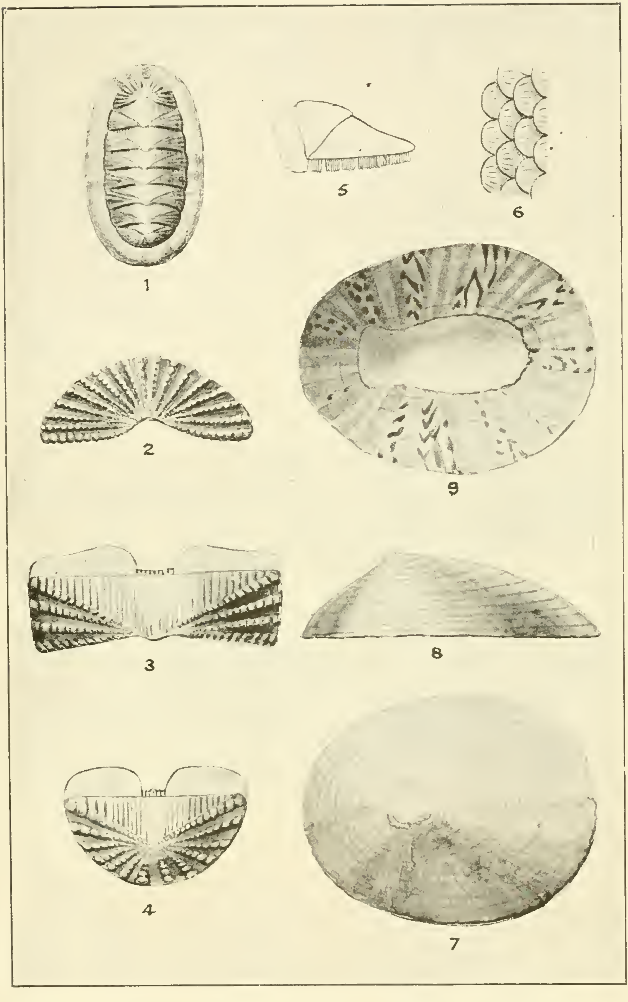

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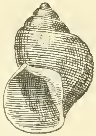
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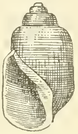

Isidora novæ zealandiæ.


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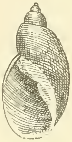

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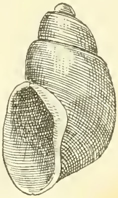
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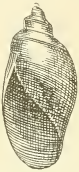

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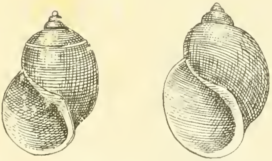
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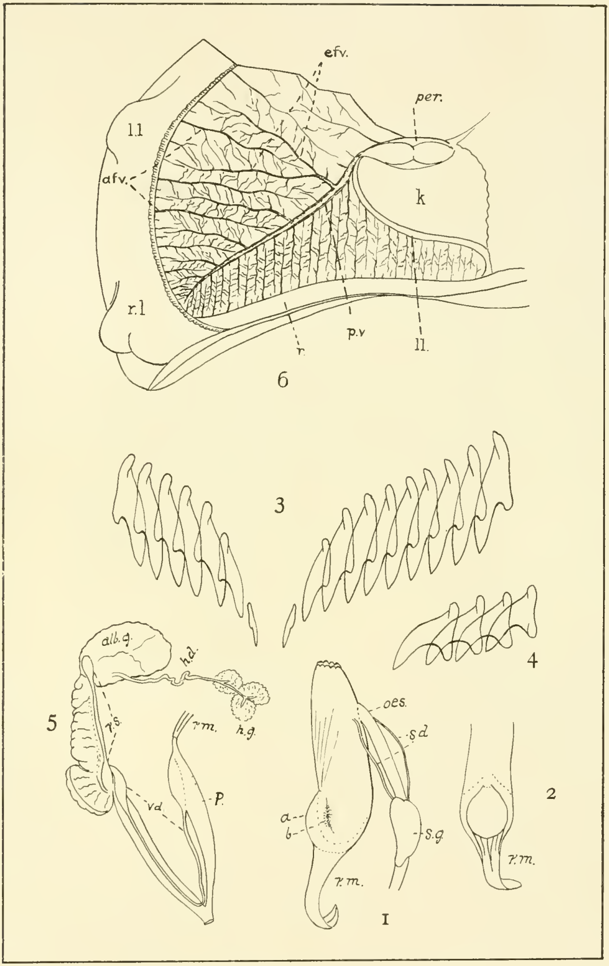

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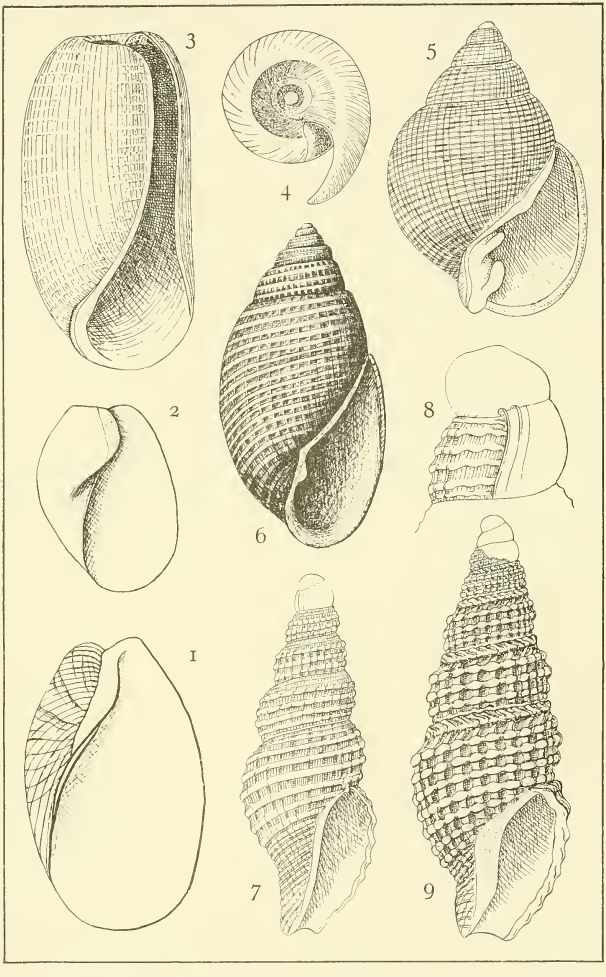

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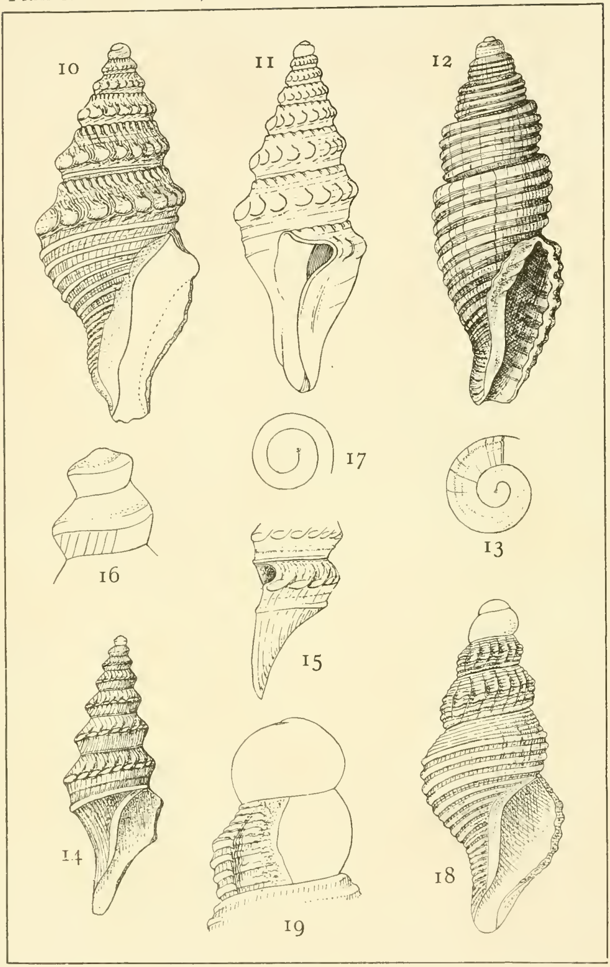

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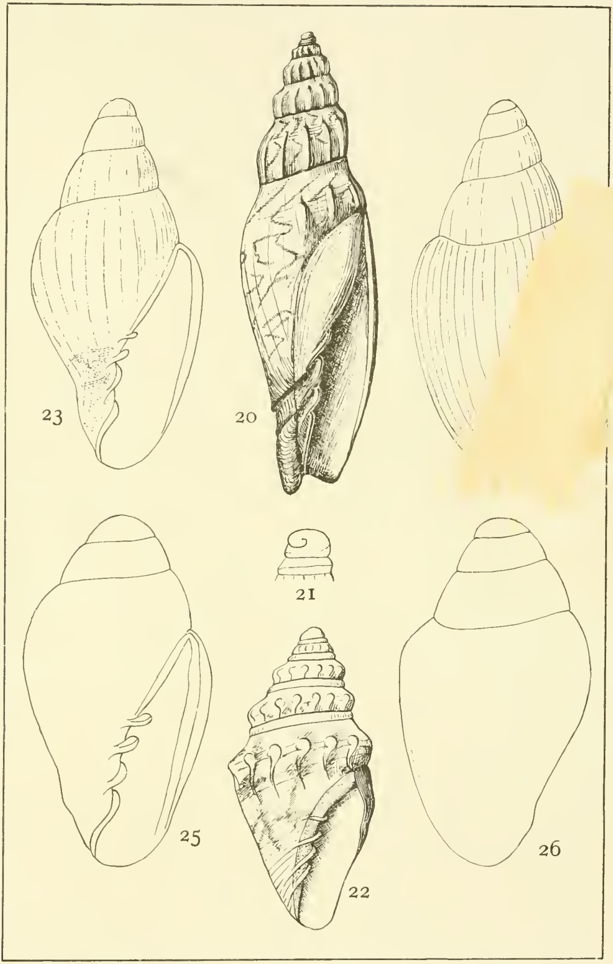

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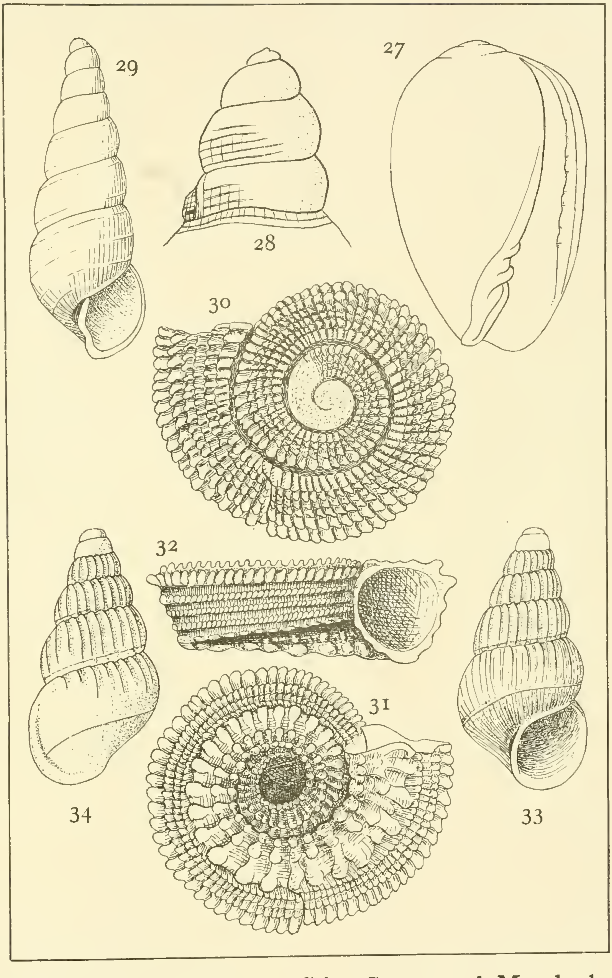

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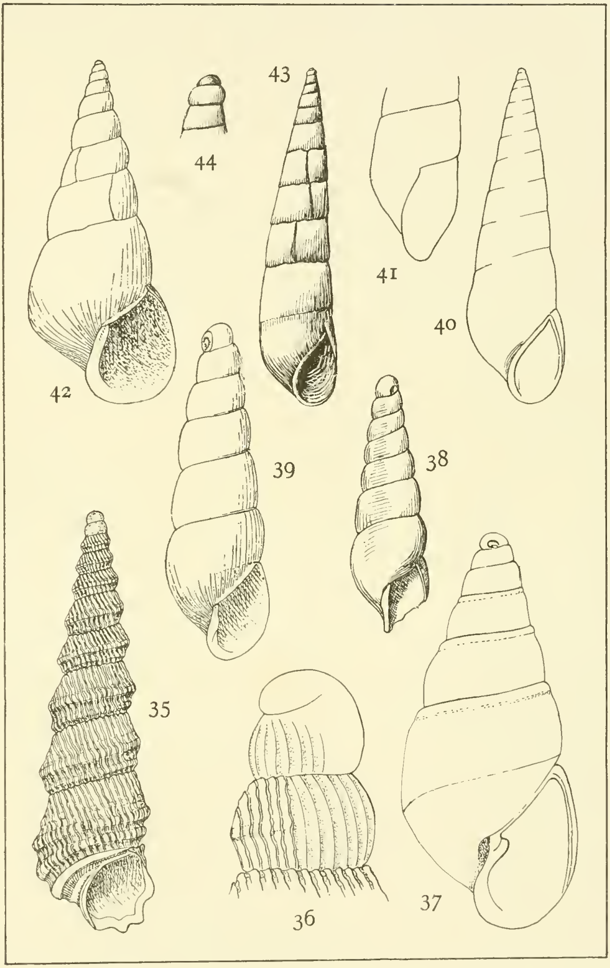

DEEP-SEA MOLLUSCA.—Suter and Murdoch.

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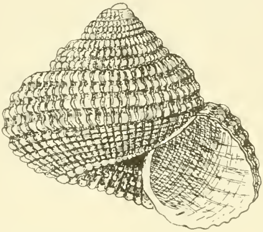

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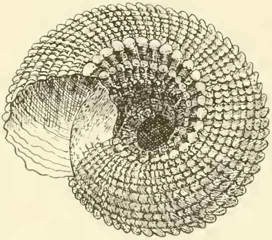

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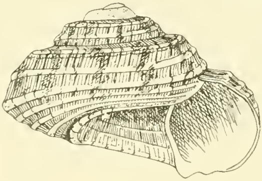

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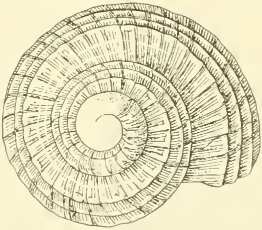

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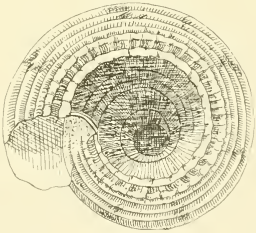
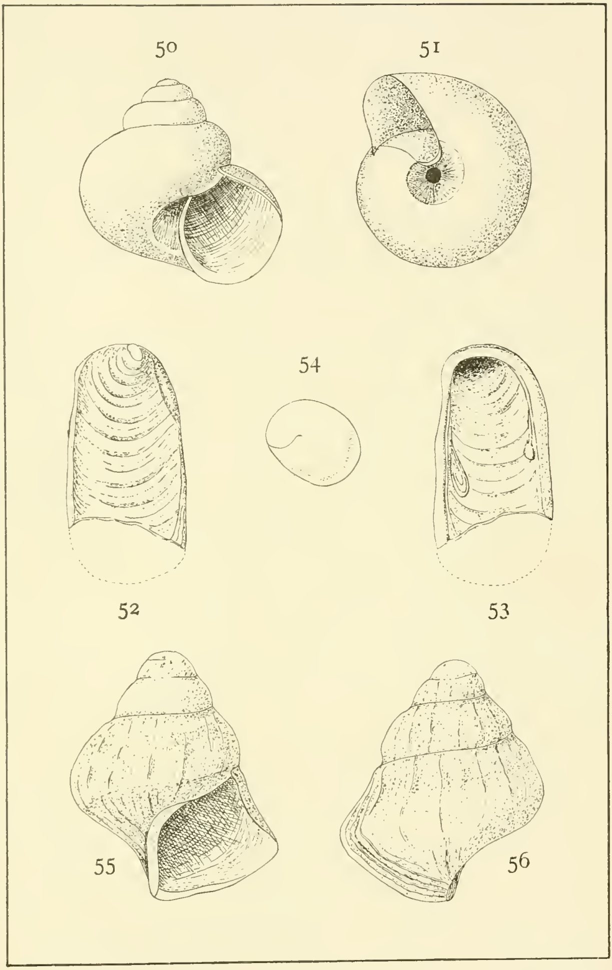
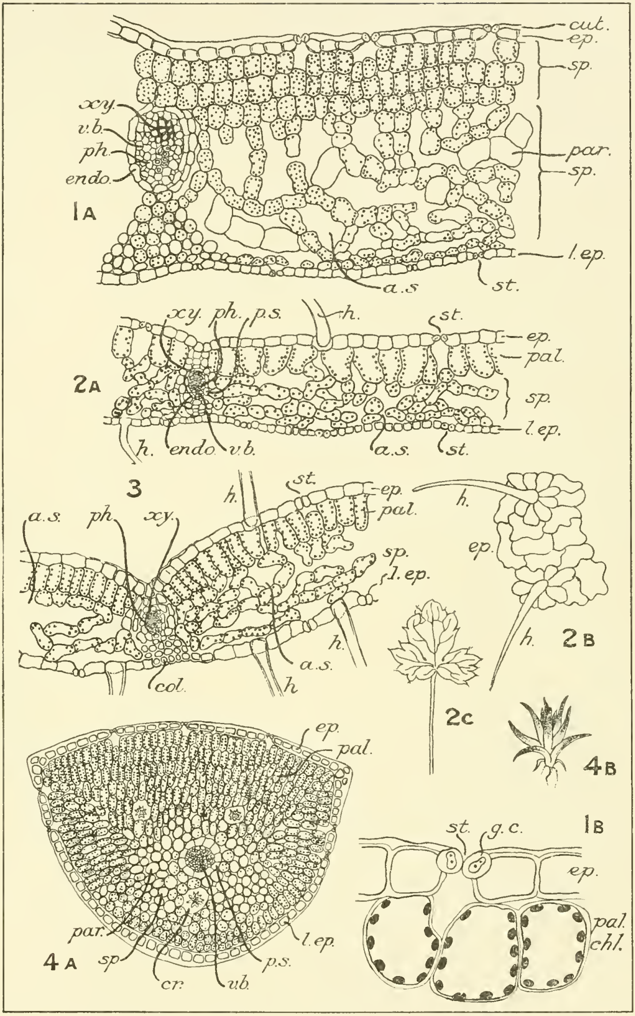


DEEP-SEA MOLLUSCA.—Suter and Murdoch.

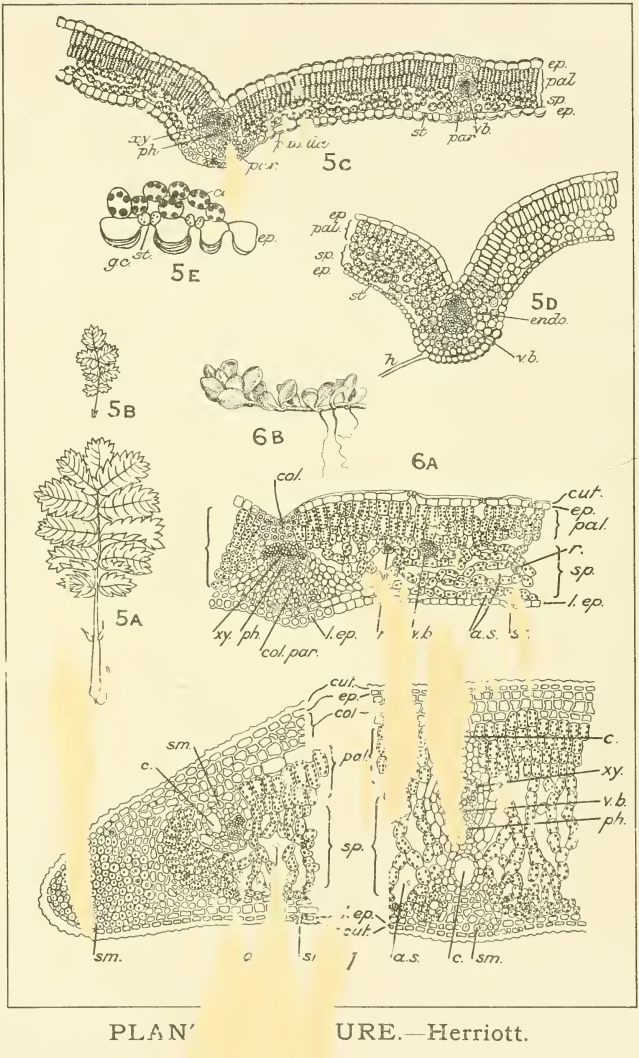
7.—PL.



DEEP-SEA MOLLUSCA.—Suter and Murdoch.



PLANT-STRUCTURE.—Herriott.



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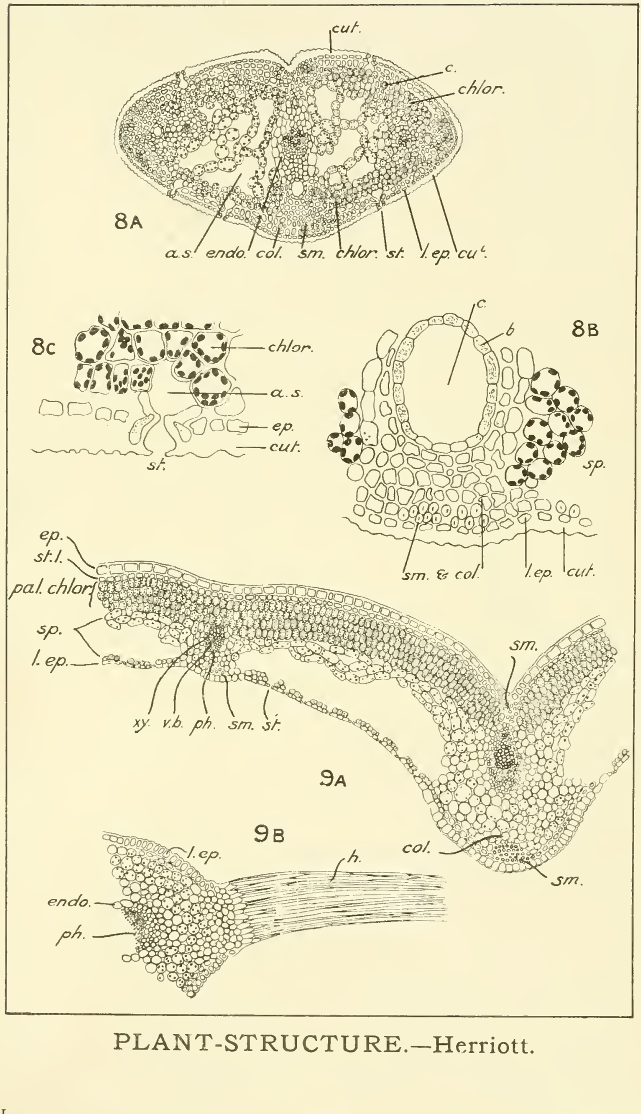

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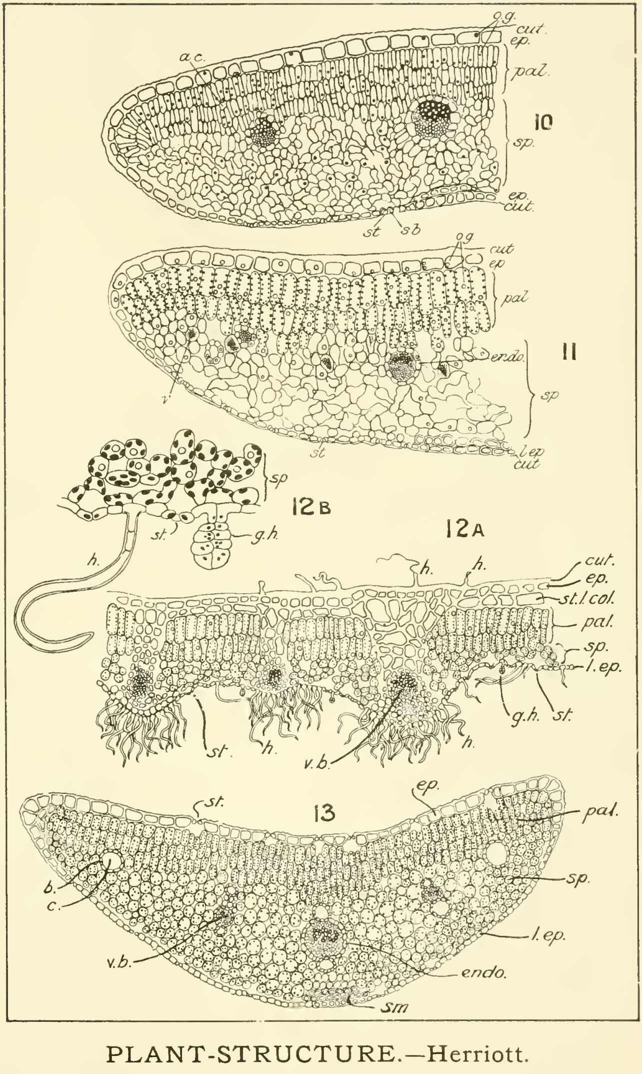

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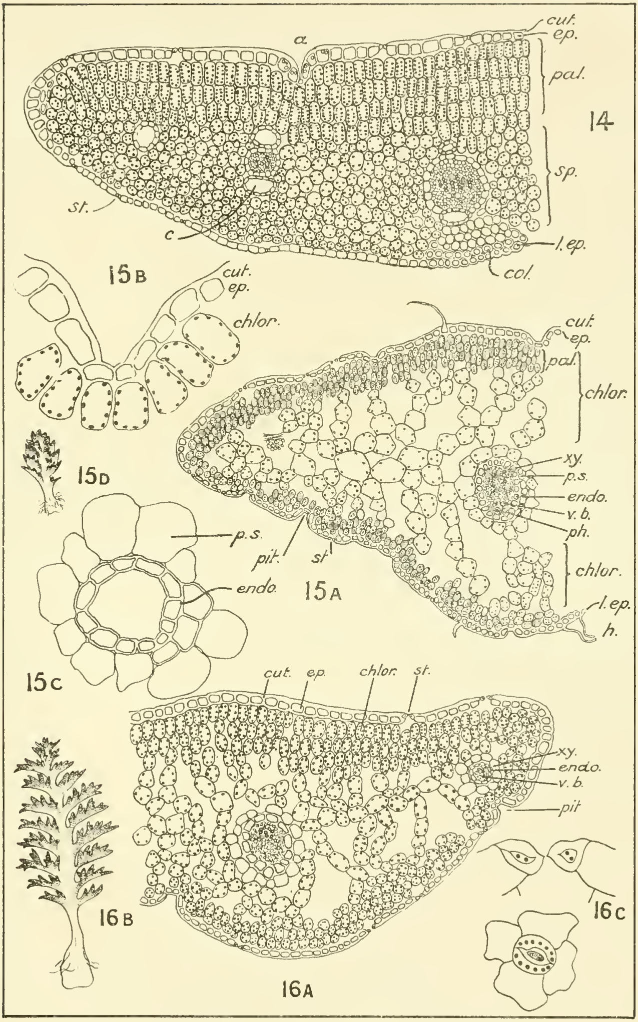

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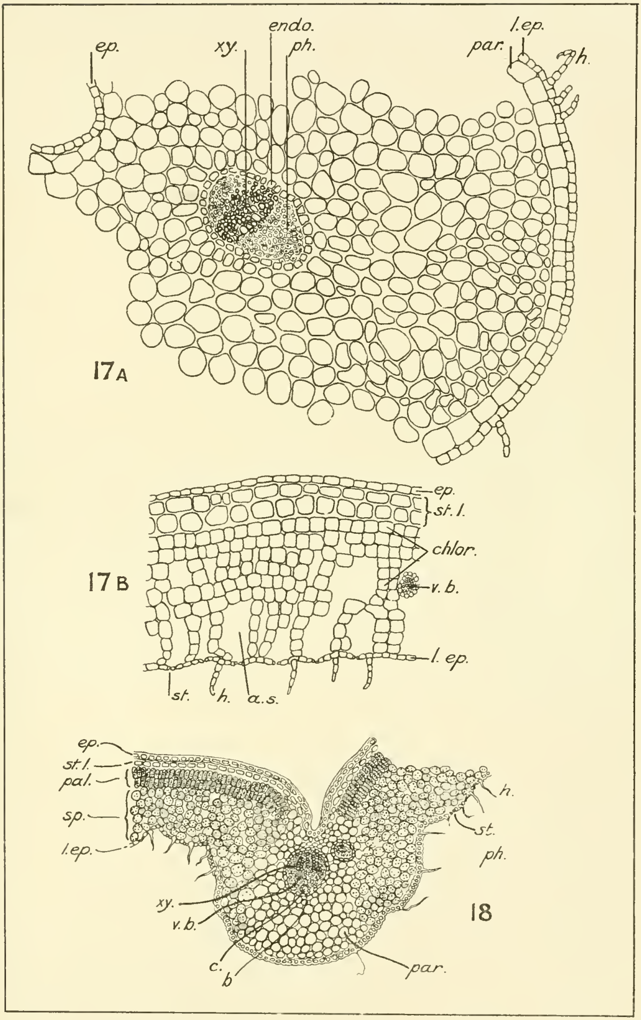

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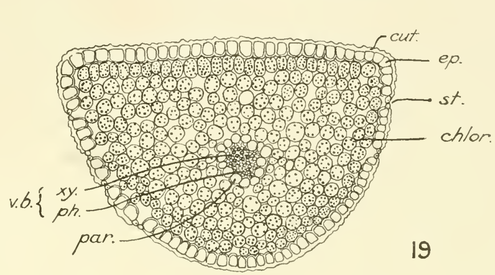

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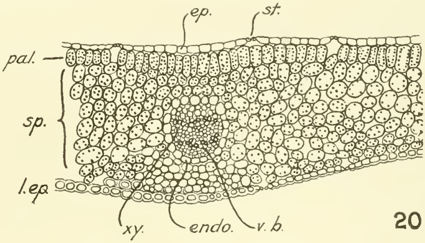

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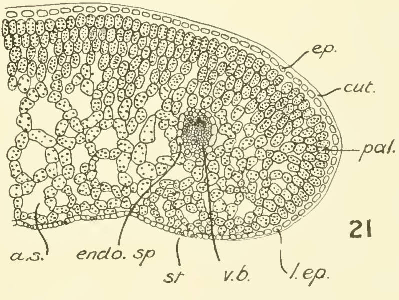

21

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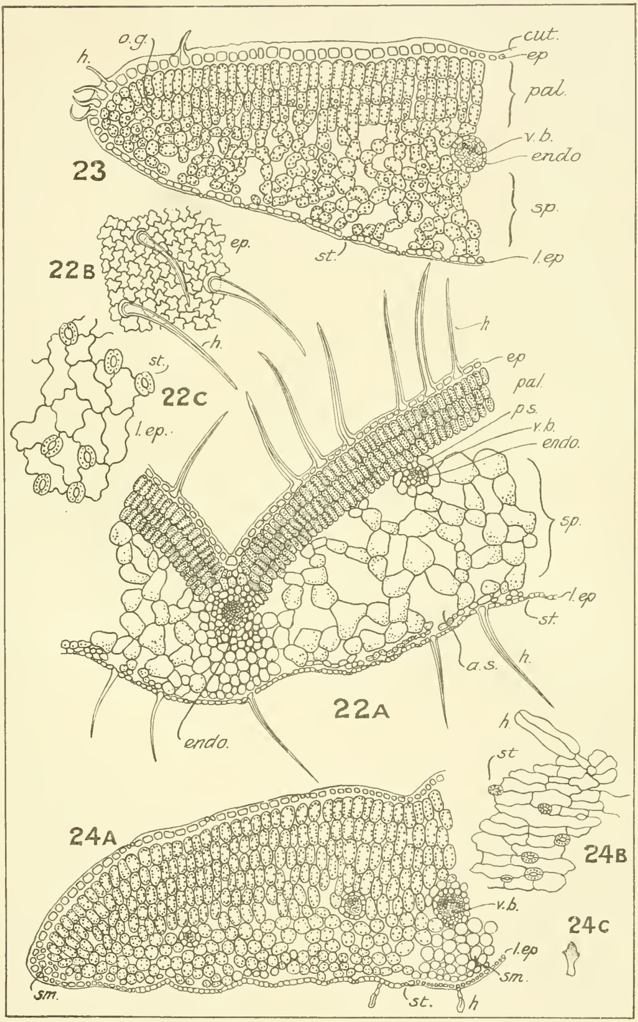

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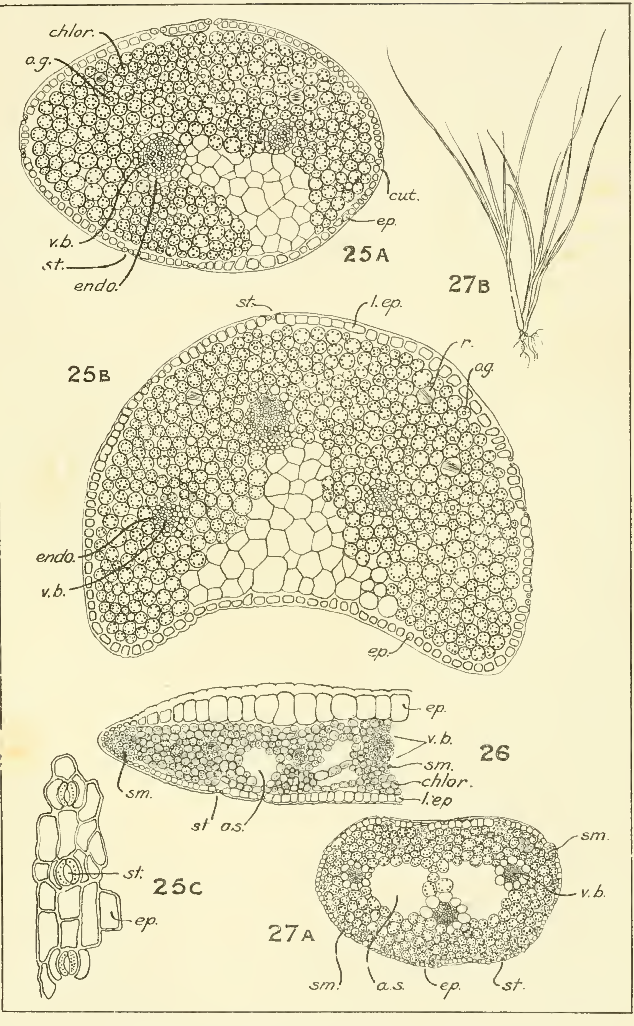
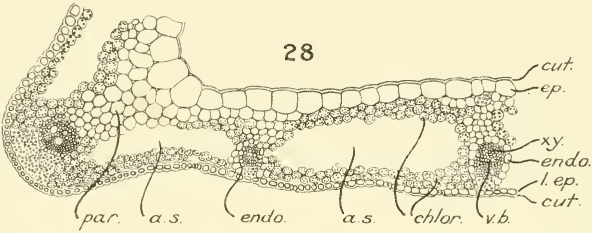


PLANT-STRUCTURE.—Herriott.

28



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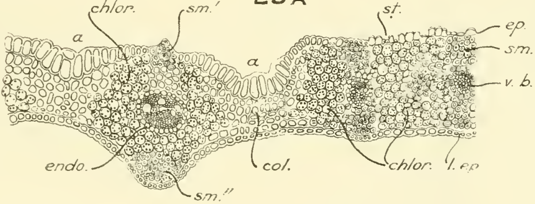

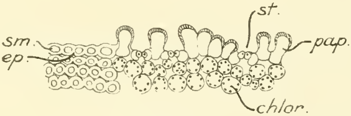

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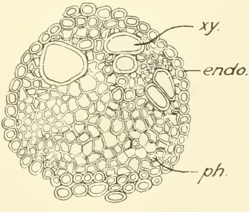
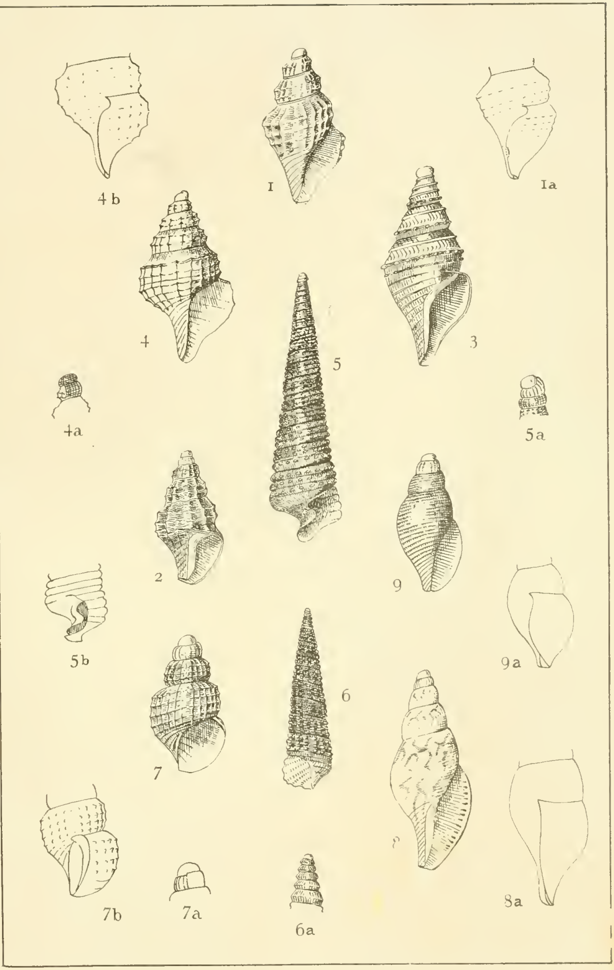
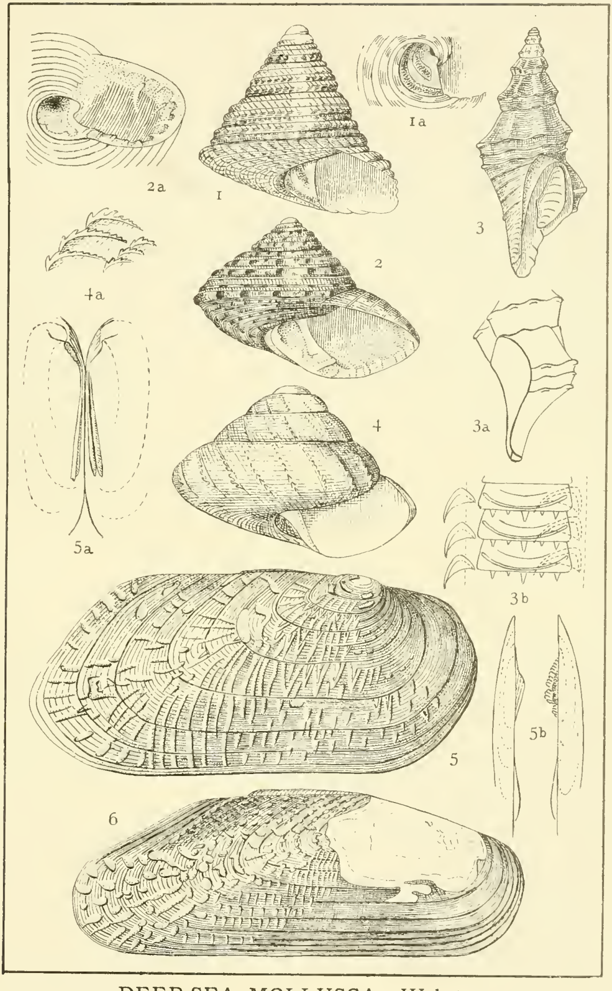


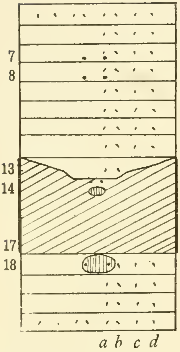
PLANT-STRUCTURE.—Herriott.



DEEP-SEA MOLLUSCA.—Webster.



DEEP-SEA MOLLUSCA.—Webster.



Tokea maorica.

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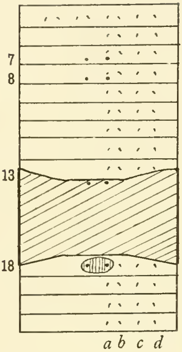

Tokea decipiens.

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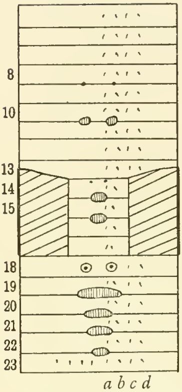
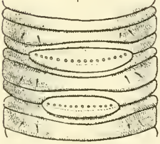


Rhododrilus similis

3

4



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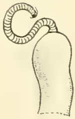
6

7

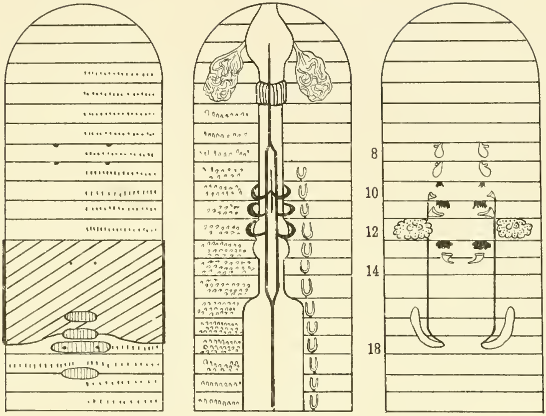
8



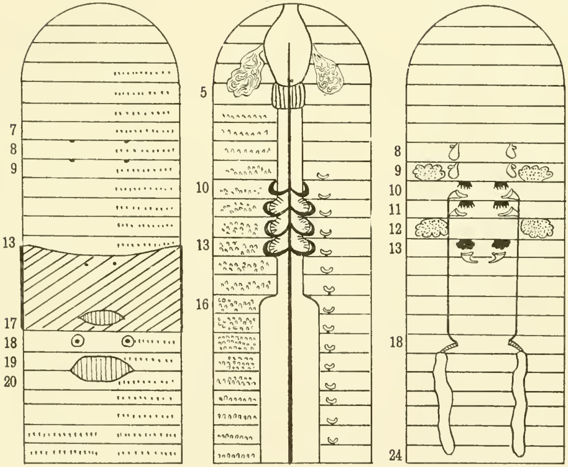
9

10

EARTHWORMS.—Benham.



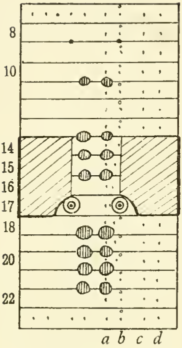
Diporochæta gigantea.



Diporochæta shakespeari.

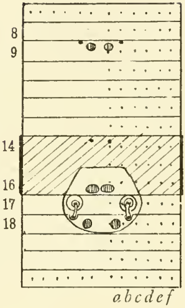
EARTHWORMS.—Benham.

1



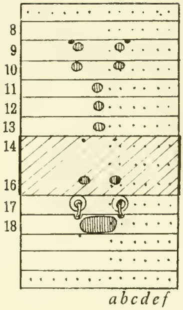
Rhododrilus parvus.

2

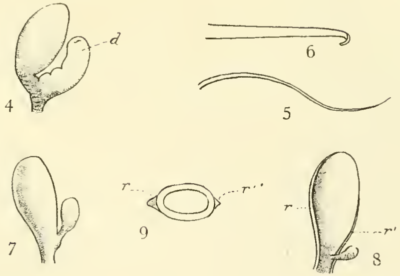


Dinodriloides annectans.

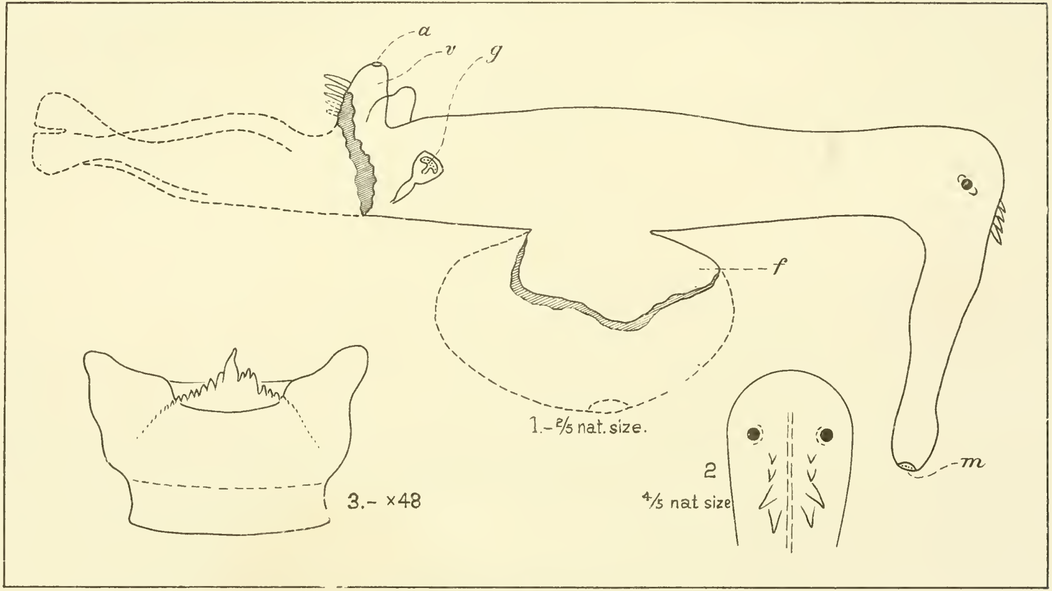
3



Dinodriloides beddardi.

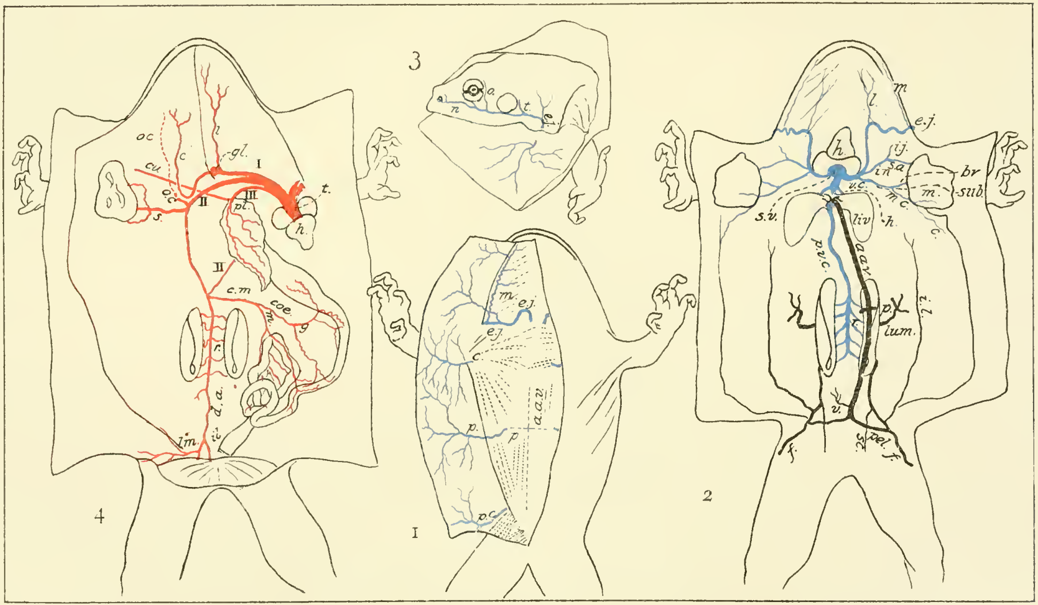


EARTHWORMS.—Benham.

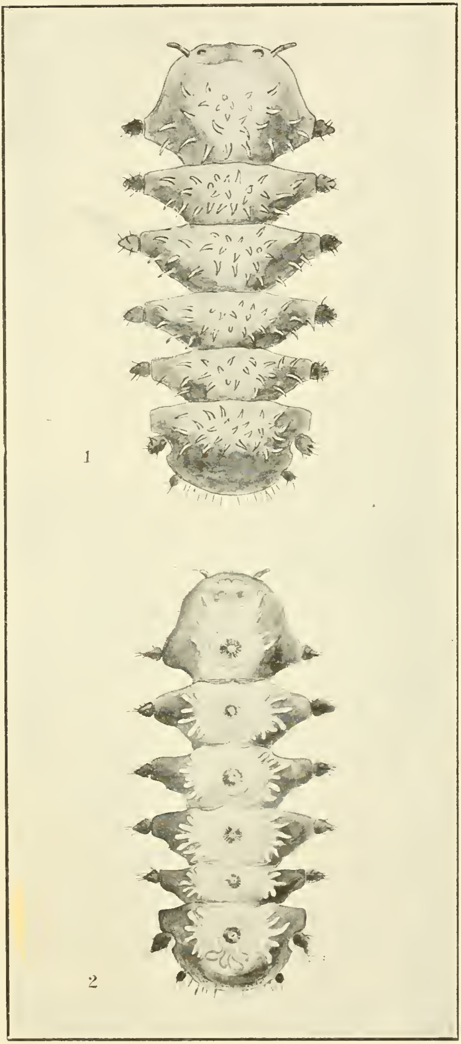


FIROLA CORONATA.—Benham.

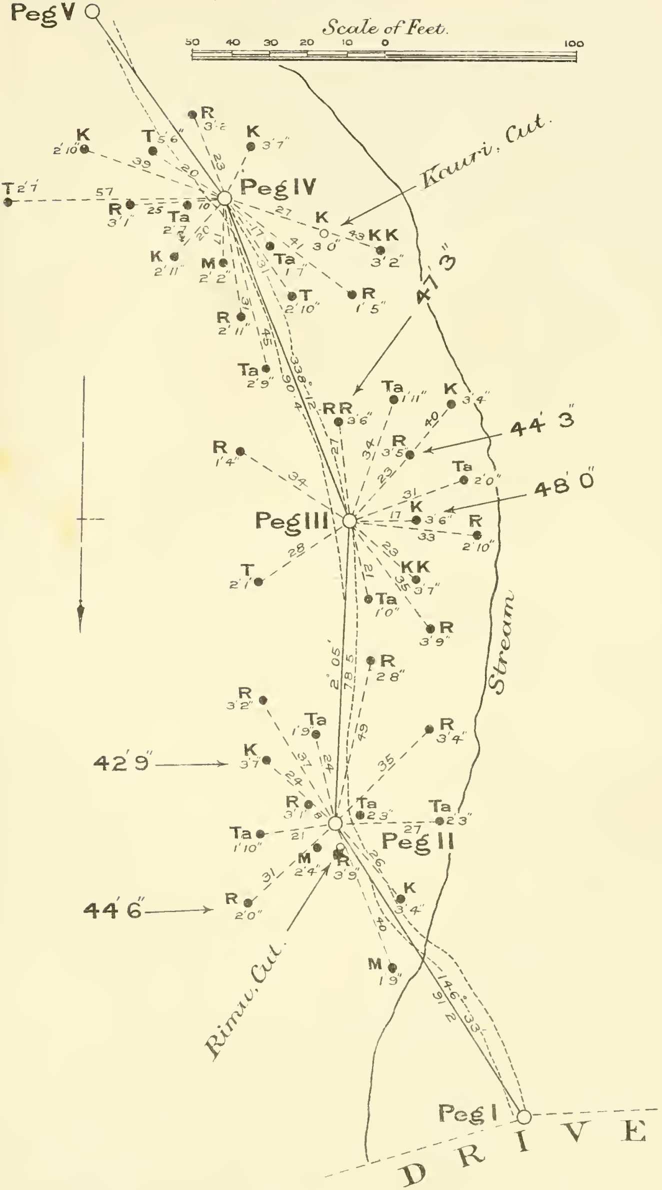
LEPIDOPTERA.—Howes.



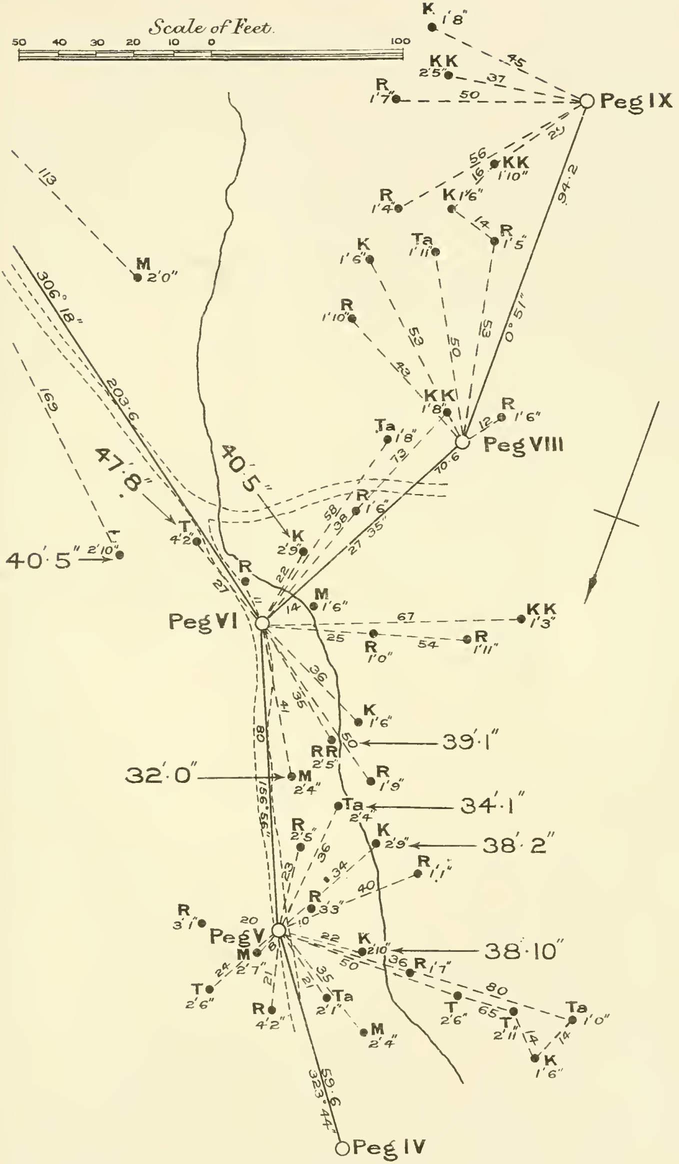
ANATOMY OF HYLA.—Marriner.



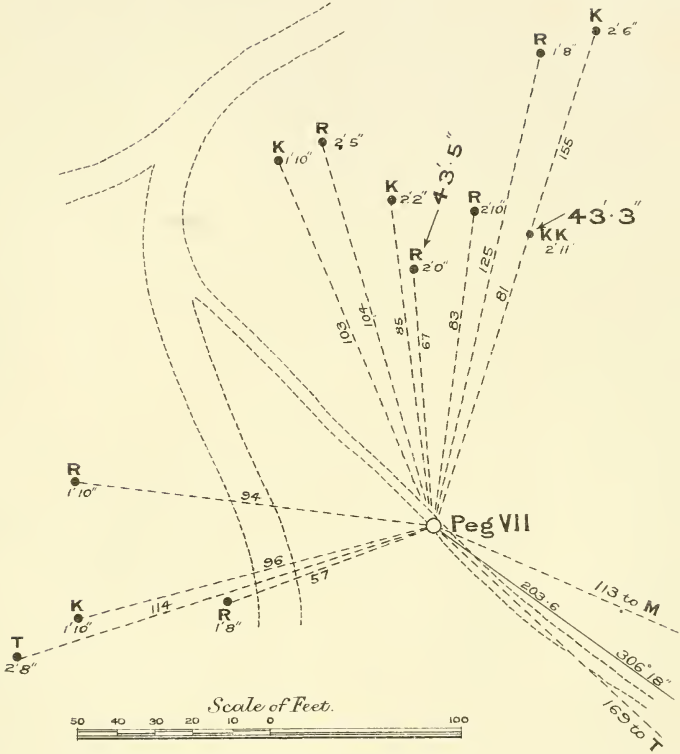
12—Pl. LARVA OF ? CURUPIRA.—Chilton.



TREES IN AUCKLAND DOMAIN.—Stewart.



TREES IN AUCKLAND DOMAIN.—Stewart.



Totara	thus	T
Kauri	„	K
Rimu	„	R
Miro	„	M
Tanekaha	„	Ta
Rewarewa	„	RR
Kahikatea	„	KK
Girth at height of 2 ft.	„	2'6"
Calculated height	„	38'·2"

TREES IN AUCKLAND DOMAIN.—Stewart.

Kauri: 42 years old, diameter 10 in.

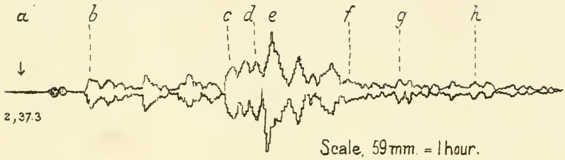
Rimu: 42 years old, showing 42 rings; diameter 15 in.

TREES IN AUCKLAND DOMAIN.—Stewart.

3.—Pl.

TREES IN AUCKLAND DOMAIN.—Stewart.

LEAF VARIATION IN COPROSMA.—Cockayne.



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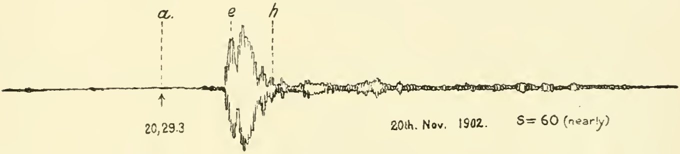

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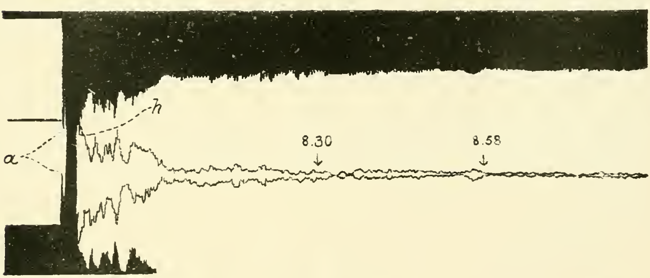

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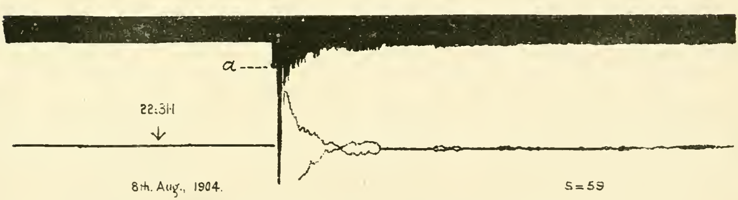
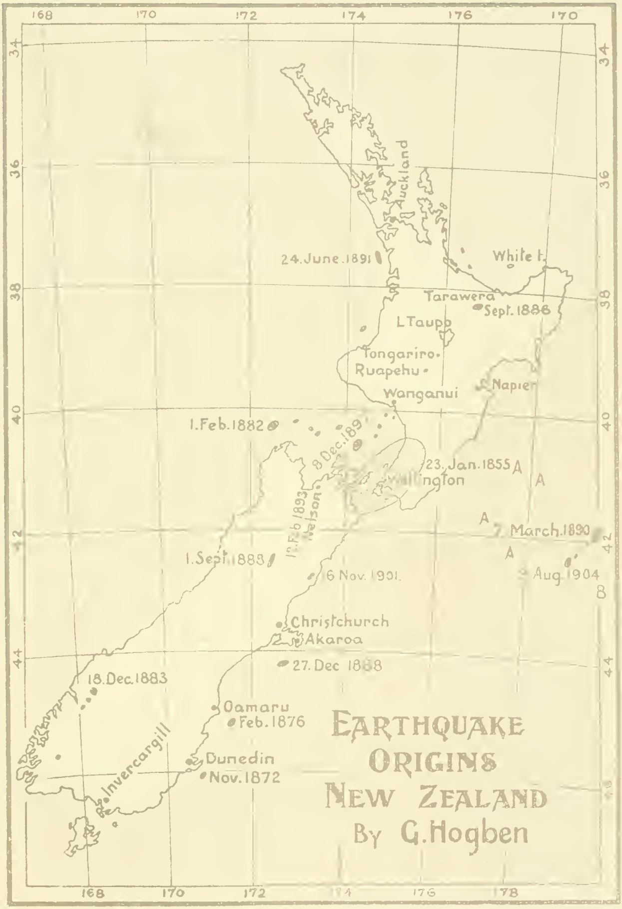


NEW ZEALAND EARTHQUAKES.—Hogben



NEW ZEALAND EARTHQUAKES.—Hogben

PORTOBELLO FISH HATCHERY.—Thomson.

PORTOBELLO FISH HATCHERY.—Thomson.

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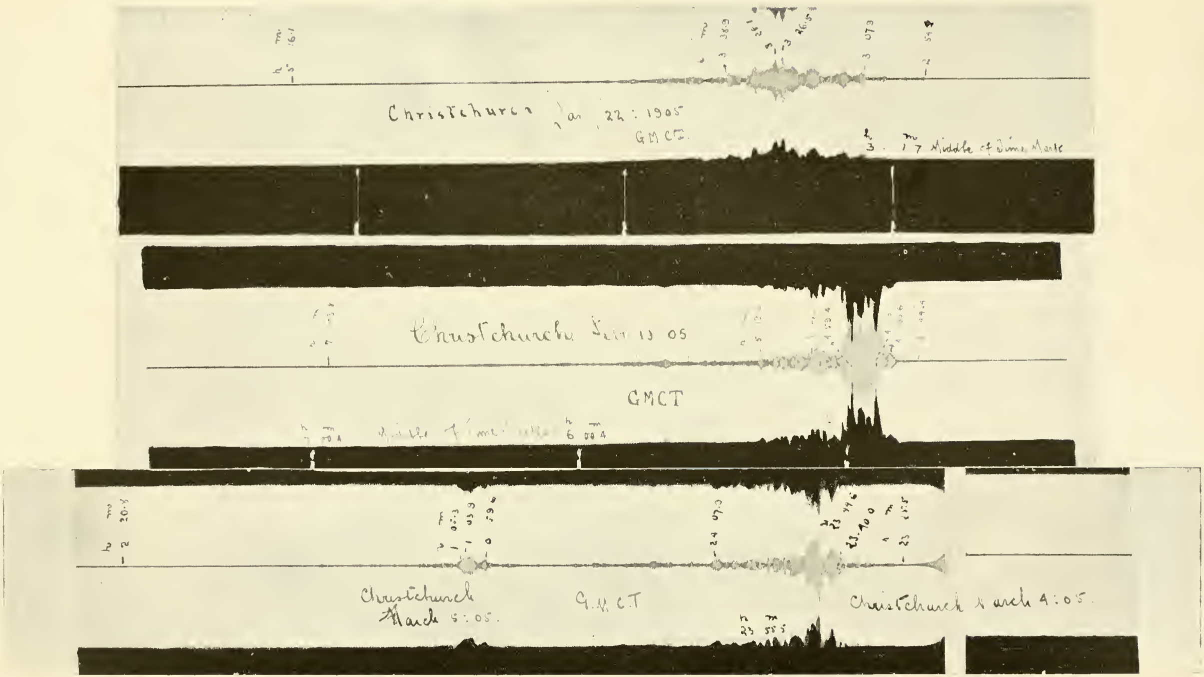
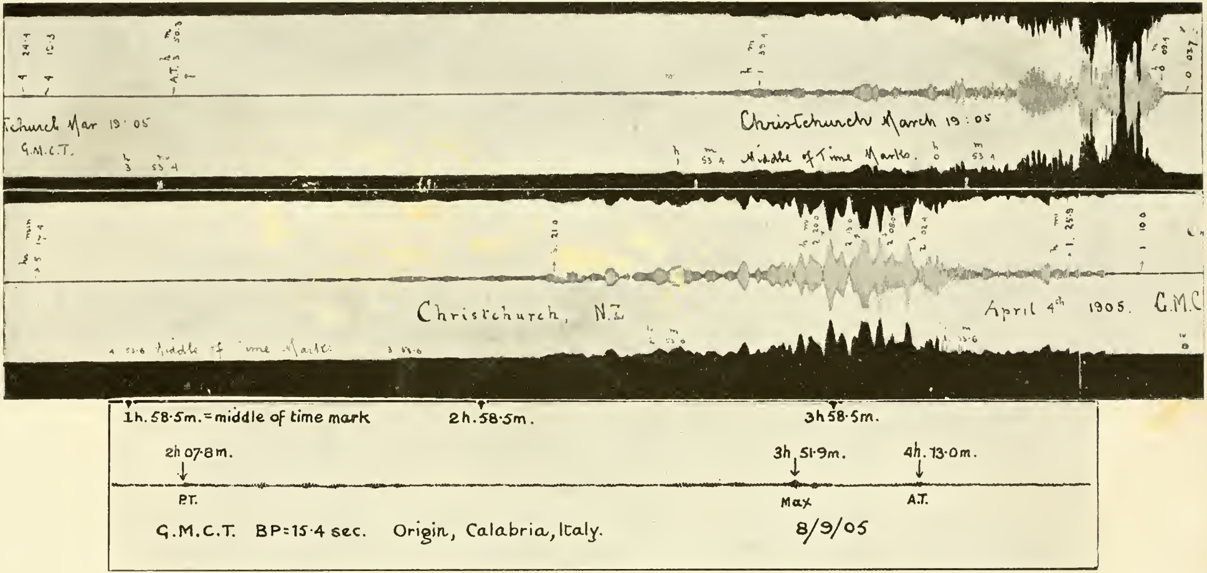
PORTOBELLO FISH HATCHERY.—Thomson.

PORTOBELLO FISH HATCHERY.—Thomson.

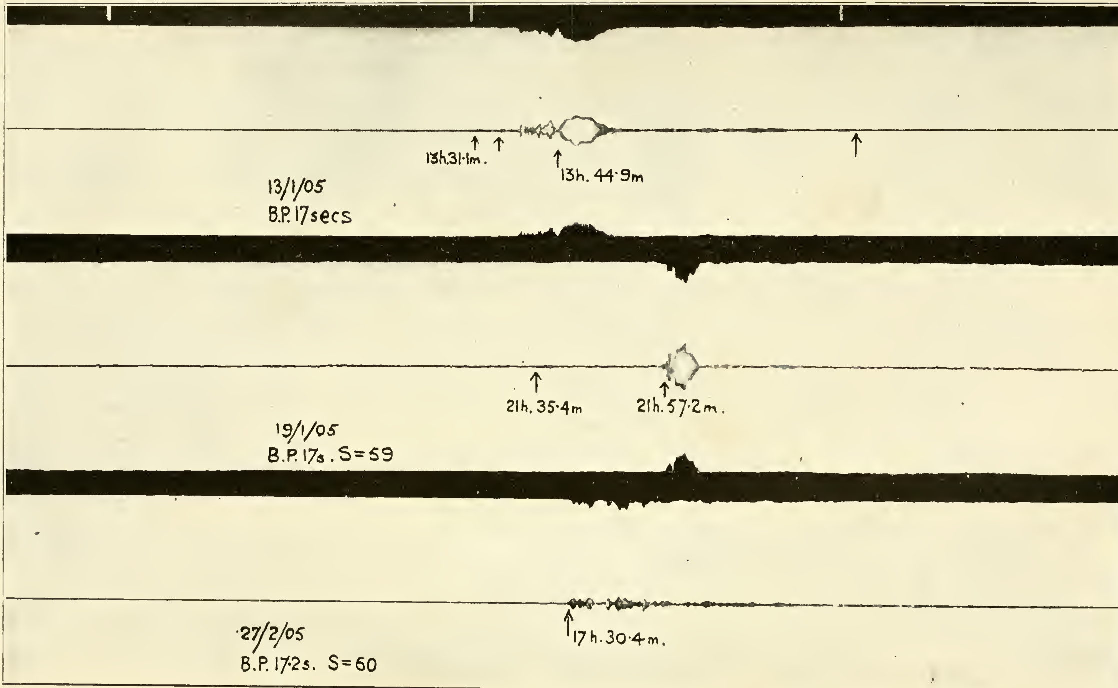
MAORI EEL-GOD.—Newman.



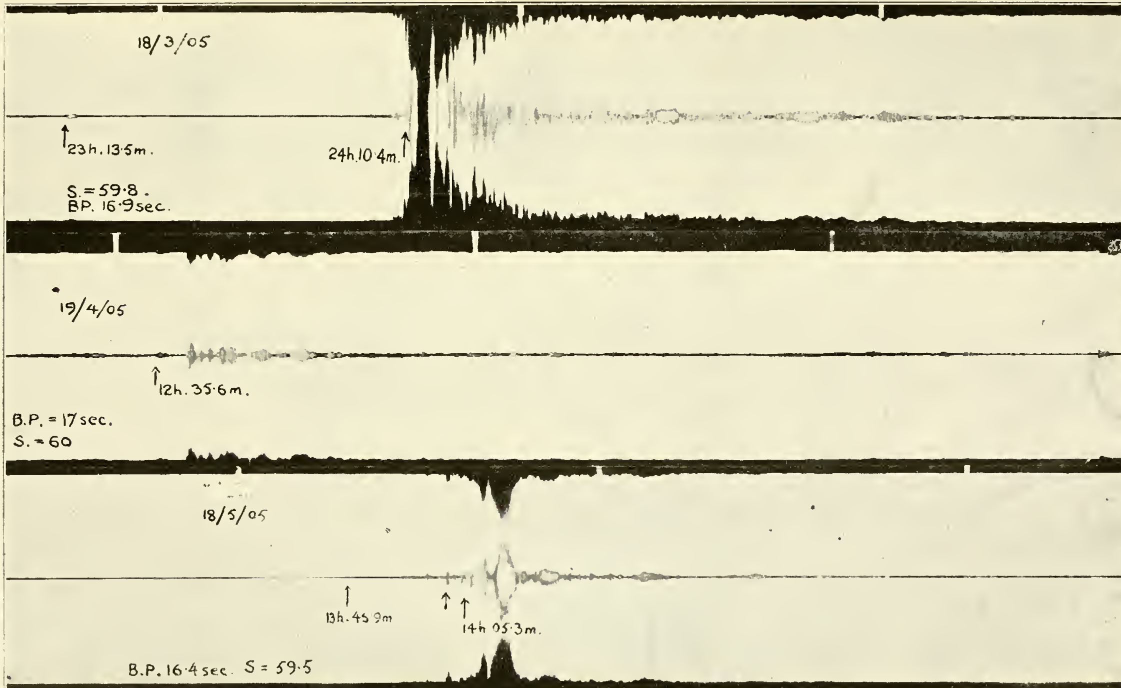
SEISMOGRAMS.—Christchurch Observatory.



SEISMOGRAMS.—Christchurch Observatory.



SEISMOGRAMS.—Wellington Observatory.



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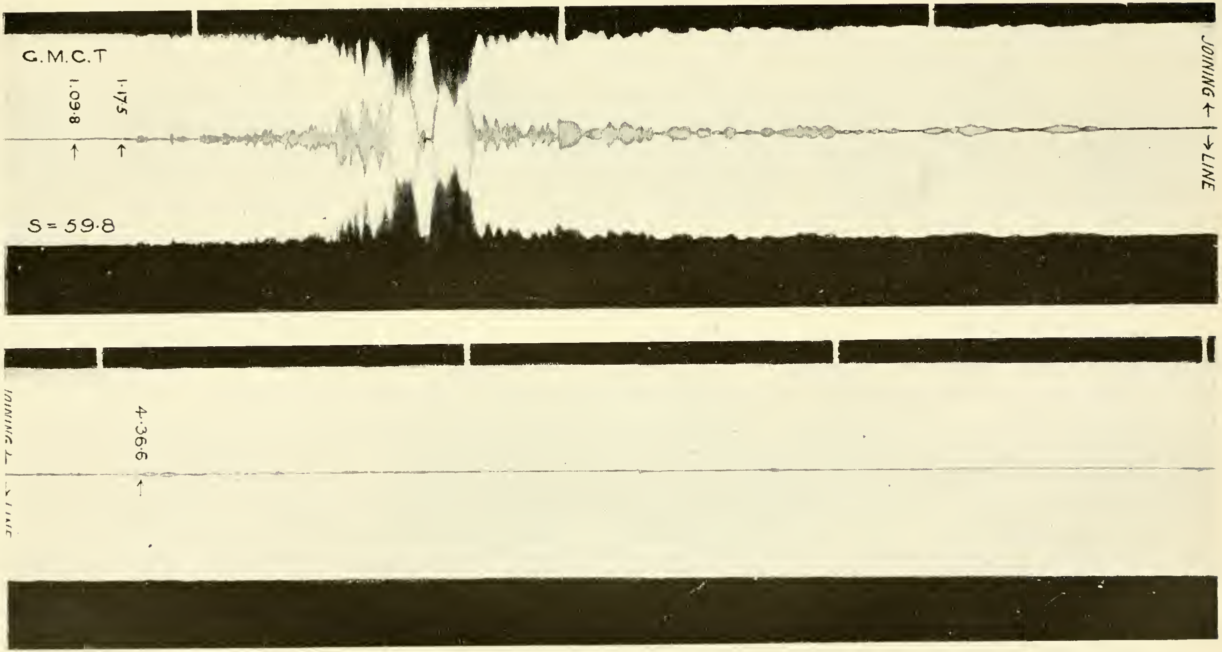
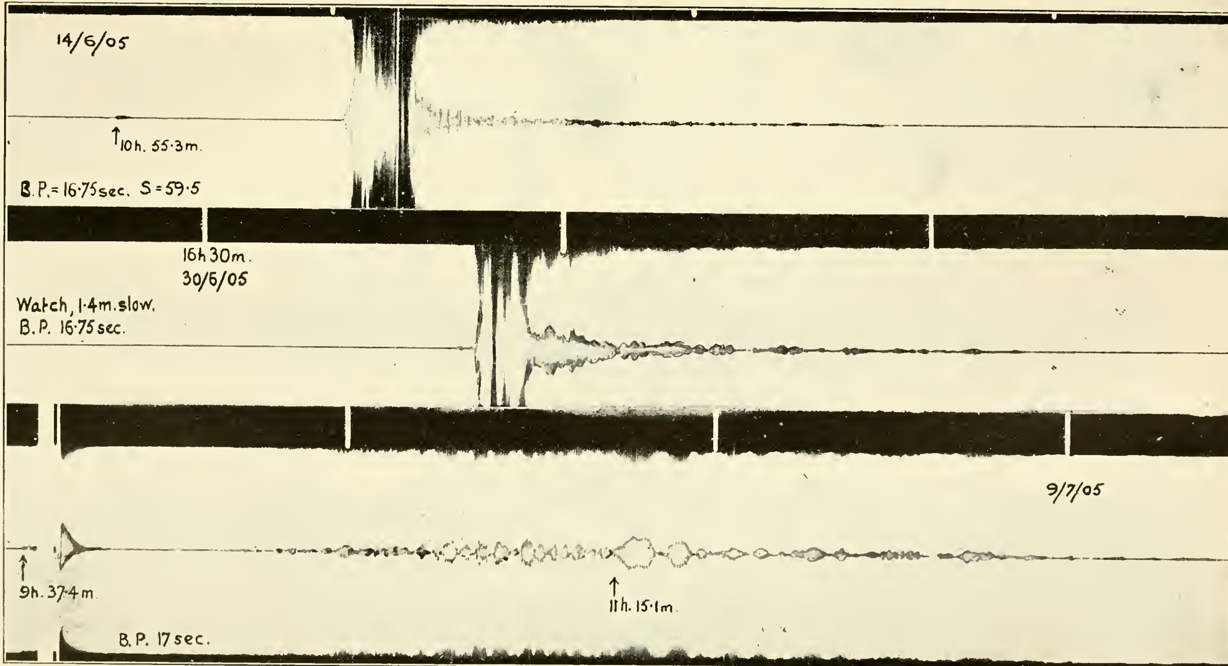


4th April, 1905.

SEISMOGRAMS.—Wellington Observatory.



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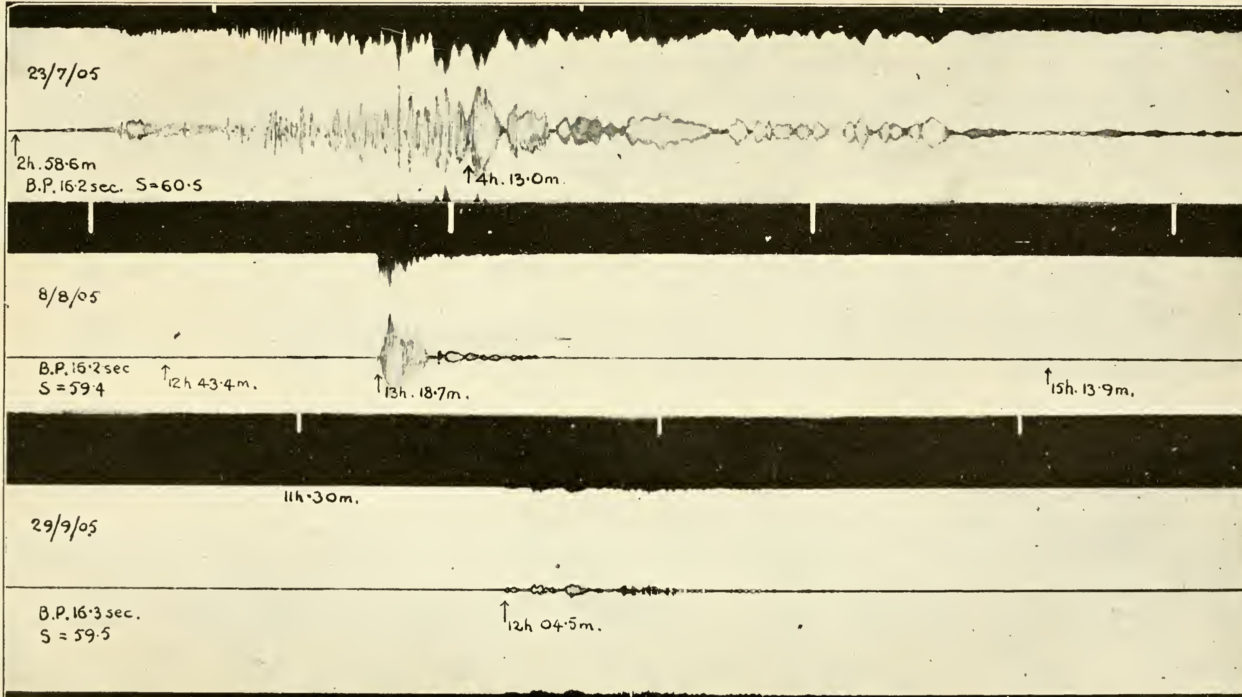

SEISMOGRAMS.—Wellington Observatory.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1905

VOL. XXXVIII

(Twenty-first of New Series)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

A. HAMILTON

Issued June, 1906

WELLINGTON
JOHN MACKAY, GOVERNMENT PRINTING OFFICE
KEGAN, PAUL, TRENCH, TRÜBNER, & CO., PATERNOSTER HOUSE
CHARING CROSS ROAD, LONDON