TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. XXIII.

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To whom all communications for transmission to the Royal Society of Victoria, from all parts of Europe, should be sent.

ERRATA AND ADDENDA.

On page 251, after the 11th line, insert the following:

Analysis of Lilicur Tripolite—

Silica	87·980
Water	9·380
Ferric Oxide	1·350
Alumina	1·150
Lime	1·064
Magnesia	0·380
Carbonic Acid	trace
Potash	trace
Soda	trace
	101·304

On page 251, in 5th line, for "6 per cent." read "3 per cent."
On page 252, in 5th line from below, for "sappings" read "cappings."
On page 253, in 10th line from below, for "warke" read "wacke."
On page 254, in 13th line, for "recticular" read "lenticular."
On page 255, in 15th line, for "Baltryllium" read "Bactryllium."
On page 260, in 17th line, for "Steene" read "Steane."
On page 266, in 7th line from bottom, for "Histriae" read "Histrix."
On page 266, in 14th line, for "irresistible" read "irreversible."
On page 266, in 15th line from bottom, for "Lepidepterae" read "Lepidoptera."
On page 267, in 5th line, for "generation" read "generator."
In the index of the map inserted opposite page 250, the Upper Pliocene capping should be represented by the letter D and space filled in with dots, while the Post Pliocene formation should be marked by the letter E and space filled in with vertical line shading.

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Royal Society of Victoria.

1886.

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Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

PROFESSOR KERNOT, M.A., C.E.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held 26th October, 1886.)

THE progress of Science, though a natural and orderly development, does not take place at a uniform rate. New discoveries do not succeed each other with the regularity of the seasons. On the contrary, there are often long periods of apparent stagnation, or at least of but little visible advancement, with intervening epochs of brilliant success. Just as the miner often labours for weeks and months with insignificant returns, and then by a single stroke of the pick unearths a gem of fabulous value, so the scientific investigator may spend weary years of patient research with but little to show for his toil, and then at one happy stroke dazzle the world by some brilliant discovery. Incalculable labour is often expended in following up a wrong clue, in tracing down to the bitter end a path that leads nowhere. Such labour is not really lost. When there is but a limited number of conceivable alternations, each one that is thoroughly investigated and proved false, brings us a step nearer the desired truth, and the happy discoverer of the great law or principle owes much to the often forgotten labours of his predecessors, who exhausted the other possibilities, and branded the false tracks with the words, "No road this way."

Then, again, a vast deal of valuable but unobtrusive work is continually being done in the way of collecting data, of observing, recording, and tabulating facts which may at some future time become the basis of vast and most important generalisations, just as in bygone ages the elaborate and conscientious observations of Tycho Brahe were the necessary preliminary to the far-reaching generalisations of Kepler.

The past year has been one of the comparatively uneventful periods in the annals of scientific progress. The work done has been great, but not brilliant; sound and useful, but without startling results. We have not to record any new departure of special importance, but merely an honest continuance of the old work. Principles considered doubtful or promising are being tested. Evidence is slowly accumulating for or against. The established truths of science are resting on an ever-widening basis, while theories and suggestions of various kinds are being constantly tested by comparison with observed facts. Thus not only are the bounds of knowledge slowly but surely extending, but within those bounds the light is ever growing clearer, and probabilities are steadily ripening into certainties.

It is, I think, to be anticipated that with the extension of knowledge and the spread of research brilliant discoveries will become more and more rare. The early investigators are like the pioneers on a newly-discovered goldfield. They, so to speak, secure the great masses of precious metal, leaving the impalpable dust which is finely disseminated throughout the rock to be laboriously extracted by their successors. Far be it from me to detract from the honour due to the scientific worthies of old. They, doubtless, like the pioneers on a new and inaccessible goldfield, encountered difficulties and perils their successors know nothing of. On the other hand, the field was to them virgin soil, that had never been searched or tested before.

But while the past year has not been characterised by any very startling discovery, it has been rendered notable by physical phenomena of a remarkable and stupendous nature. Firstly, it is stated that the great lake of molten lava at Kilauea, in the Sandwich Islands, has disappeared, and that nothing but a dark and empty chasm is to be seen where once this mighty cauldron seethed and hissed. Then, more recently, we have the tremendous volcanic convulsion in the North Island of New Zealand, a convulsion as unexpected as it was disastrous. It had always been supposed that geysers and terraces indicated the slow dying out of volcanic energy, the tranquil old age that was the immediate precursor of total extinction. Local traditions harmonised with scientific theories in this respect; when suddenly an explosion takes place, and the whole face of the country is altered. A huge fissure, or chasm, six miles long, and of varying width, almost perfectly straight on one side, while the other is most irregular, has been formed, while Lake Rotomahana and the famous terraces have disappeared in its depths. From it rise dense clouds of steam, through which are dimly seen seas of boiling mud far beneath. The whole district for many miles has been covered with a thick layer of dust or mud, destroying all vegetation, and rendering the country a desert. The phenomenon has been very fully investigated by Dr. Hector, F.R.S., the Director of the Geological Survey of New Zealand, and is pronounced by him to be hydrothermal in its nature—or, in other words, to partake of the character of a most gigantic steam boiler explosion—and the cause is stated to have been the very heavy rains which followed the longest period of drought that had been known for many years. This conclusion has been disputed in some quarters, and we wait anxiously for further particulars, which have been promised.

In addition to this great explosion, a disastrous earthquake is reported at Charleston, in the United States, and a volcanic outburst at Tonga, in the South Seas.

The doctrine of geological authorities that the volcanic energy of the globe is slowly dying out is, no doubt, true; but the above-mentioned events show that its gradual declension is liable to be interrupted by numerous spasmodic outbursts, which may be locally disastrous.

An interesting event of a different character has recently taken place in Paris. M. Chevreul, an investigator of the highest eminence in organic chemistry and in the study of colours, has attained the age of one hundred years, being still in the possession of his faculties, and actively engaged in scientific work. This occurrence led to a series of public festivities, in which the whole scientific community took part. A congratulatory address, a statue of the veteran scientist, and an exhibition of materials and processes illustrating his discoveries and their applications, are mentioned.

An important suggestion has recently reached us from New South Wales. Professor Liversidge, of the University of Sydney, has made overtures to the various scientific bodies in Australia, with a view to the institution of an Australian Association for the Advancement of Science, on the lines of the well-known British Association. Its policy is defined as follows:—"The Association contemplates no interference with the ground occupied by other institutions. Its objects are—To give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the British Empire with one another, and with foreign philosophers; to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress."

Like the British Association, its Australasian offspring will hold annual gatherings in rotation at the various great centres of population. The first group of meetings are proposed to be held in Sydney in 1888, the centenary year, and will occupy about a week. Delegates from all parts of the colonies are expected. The following year the meetings will be in Melbourne, and so on. Should this movement, which has been welcomed heartily in all quarters, be carried out, it will do much good in ways too numerous to mention.

POSITION AND PROSPECTS OF OUR SOCIETY.

Under this head I have nothing very striking to relate. Our meetings are fairly well attended, our library steadily grows, and our published Transactions are in request by kindred societies in all parts of the world.

It was recently pointed out that the lightning conductors in use in Melbourne were in many cases very defective, and in some an actual source of danger. The Society thereupon printed and circulated one thousand copies of the code of rules drawn up by a conference of eminent electricians, physicists, and architects, that met in London about four years since. It is to be hoped that this action will result in a reform that is much needed.

Valuable papers on Geology, Zoology, Botany, and other subjects have been discussed during the past year at the general meetings, while many questions of engineering have been considered by Section A, the branch of the society specially concerned with such matters.

A suggestion having been made by Professor Huxley, President of the Royal Society, for the affiliation of societies having similar aims, a correspondence has taken place, which it is hoped may eventually lead to some arrangement whereby the various local societies may receive some recognition and encouragement from the great parent body.

We have to record the death of Mr. J. B. Were, C.M.G., who was one of the earliest promoters of our Society, and who, for his services, was elected an honorary life member. He died on the 6th December, 1885, at the ripe age of seventy-seven.

ASTRONOMICAL NOTES.

The past year has not been remarkable for astronomical events, except the discovery of numerous small comets, This fact is probably attributable to the more perfect scrutiny to which the heavens are now subjected by the large number of excellent telescopes in the hands of private observers and enthusiastic amateur astronomers, especially in England and the United States. Small comets are probably far more numerous than we suppose, as at the brightest part of their apparition many are only just visible in telescopes of large dimensions, and would escape detection altogether were it not for the almost competitive watchfulness of such observers. Perhaps the most noteworthy item of astronomical progress during the past year has been in the application of photography for mapping the stars. Some experiments in that direction at the Paris Observatory and elsewhere are full of promise, and photographic charts obtained of some rich celestial areas show that every star, down to magnitudes far smaller than can be seen by the naked eye, are faithfully depicted in their true relative positions on the sensitive plate; while it is found that some stars are photographed which, on account of their peculiar light, have not been hitherto detected in the telescope. At present, however, there are certain physical and mechanical difficulties which render all the pictures comparatively unsatisfactory. Long exposure is necessary, during which atmospheric changes often occur, and it appears at present, mechanically, almost impossible to secure such equable motion of the photographic telescope as is requisite to keep the image of a star on the same exact spot of a sensitive plate for an hour or more at a time. If greater chemical rapidity of the sensitive film, and a truly uniform motion of the telescopes, can be obtained—things we do not think quite impossible—photography promises great things for astronomy in the future.

As regards our Observatory, we have not much to record for the past year; it has been occupied, as usual, with its utilitarian work of star-cataloguing, search for, and revision of known nebulæ, observations of comets discovered, as well as its accustomed work in meteorology and terrestrial magnetism. A commencement has been made in the publication of the observations made with the great telescope since its erection in 1869. A difficulty, however, exists concerning a good and economical method of reproducing for publication the numerous drawings of celestial objects made at the telescope, the objects requiring such delicate treatment to show their nebular and cloud-like character that every method of reproduction hitherto tried gives pictures too hard and rough.

BOTANICAL PROGRESS.

Our esteemed fellow-member, Baron F. von Mueller, F.R.S., reports as follows:—

"Within the last few months the Atlas of Myoporinous plants, an ordinal group almost entirely Australian, has appeared. The discovery of the majority of the 76 species now illustrated is traceable to the activity or impulses of my department. As the 'prides of our deserts' these plants will be ever memorable, and as decorative plants they will now become better known as very desirable acquisitions to horticulture anywhere. With the same view of bringing under fuller notice for gardening efforts the very numerous species of Australian acacias, our bushy harbingers of the spring, an inconography is now under progress, for, with the approval of the Hon. Alfred Deakin, the Chief Secretary, and Minister of the department of this work, two or three decades will probably appear in the course of this year; and as of the rather more than 300 species occurring in this part of the globe hardly as yet 100 have been depictured anywhere since the end of the last century, we shall have here, from the unique richness of the material in our phytologic museum, ample opportunities for original illustrations, without demanding extra resources for the purpose, and may thus promote pictorial art also amongst us in this direction. Such a work should also bear on our wood and tan industries, and it should also enlarge to some extent the seed trades in these colonies, as even in conservatories of colder countries our often odd-leaved and profuse flowering multitudinous kinds of acacias are always greeted with delight when bursting into bloom, while in Britain and elsewhere far north the snow-decked vegetation produces, beyond the hazel blossoms, hardly any flowers.

"One portion of the *Key to the System of Victorian Plants*, announced last year, appeared some months ago; it gives the systematic index, with geographic annotations, of the (about) 1850 vascular plants known as indigenous to this colony; it is illustrated by more than 200 woodcuts, representative of the orders and sub-orders into which our native vegetation is classed. The completing portion of this work has been for some time under elaboration, and will ere long be brought out, though it needs consummate care to seize on binary characteristics, patent at a glance in the field, for evolving them in the desired dichotomous manner without much disruption of affinity in the enumeration, and thus without likelihood of leading astray in the search of the ordinal, generic, and specific position of a plant; the difficulty being increased by the necessity of framing such characteristics as will cover multifarious variability, and apply in reference to ordinal and generic groups, and also to any specific forms beyond Victoria, free nature disdaining any arbitrary system into which we may endeavour to ennarrow her. The sixth edition in the English language of the volume on *Select Plants for Industrial Culture and Naturalisation* appeared early this year, brought up to the knowledge of the present day. To some extent it was destined as a departmental literary contribution towards the London Exhibition, but still more so to satisfy a just demand of our striving and toilsome rural population, whose scope for cultural and pastoral pursuits, on which so largely the welfare of the country depends, being in our own almost winterless clime so much wider than in the colder zone of the home countries of the earlier colonists. So great has been the demand for this plain and unpretentious, but at the same time sufficiently ample and quite inexpensive publication, that the last rather large issue has become already almost exhausted, so that another edition must early be rendered available; and such a work to be complete and reliable must necessarily be kept up in consonance with the progress of discovery and research emanating from any part of the globe, only the products of the hottest tropical regions being excluded from our cultural scope.

"The third annual supplement of the *Census of Australian Plants* for 1885 was edited in the early part of this year. It advances the number of vasculares to a total of 8800 well-marked indigenous species, exactly described; to these 20 have been added since, the total of the whole Australian flora of vascular plants, when once fully known, not likely much exceeding 9000 species.

"Collections from unexplored regions are much solicited, particularly, also, from the more central regions of Australia, as therefrom also the observations on the geographic distribution, on the utilitarian purposes, and on the degree of variability of the known species can be followed further out, always with due acknowledgment of the aid thus afforded by the senders.

"Some detailed elucidations of Papuan plants from the collection of the Australian Geographical Society's Expedition under Captain Everill, obtained by Mr. Baeuerlen, and also from equally important botanic gatherings of the celebrated naturalist, Mr. Forbes, have been carried out, and the preliminaries for the elaboration of the whole dicotyledonous material are completed so that my work on *Papuan Plants,* commenced in 1875, can be well continued. Also for this participation in progressive science the vast collections of plants from all parts of the globe accumulated by me since 1840, and comprising now about half a million sheets of specimens, will be of the greatest aid. Such extensive treasures in a young colony, which far outrival those in many of the largest and oldest cities, will have an important bearing, perhaps through centuries, on education in Australia, on healthful intellectual enjoyment of generations of inhabitants in this part of the globe, and also, further, in Victoria taking an honourable, independent share in the science of the globe, on the progress of which sustenance and material wealth must largely depend in all futurity."

The Botanical Gardens, under Mr. W. R. Guilfoyle, are being improved in various ways. New lawns and walks are being constructed, and native Australian plants are carefully cultivated, and, being distinctly named, enable visitors to identify and classify them when met with elsewhere. New plants are constantly procured by exchanging with botanical gardens in other parts of the world. Specimens for educational purposes are supplied to the Training College of the Education Department and other institutions, and a large and complete collection of fibres, seeds, seed capsules, ferns, &c., have been transmitted to the Indian and Colonial Exhibition.

The Zoological Gardens in the Royal Park have also been much improved during the past year, and a large number of valuable and interesting animals from other parts of the world have been added.

ENGINEERING.

The most important event in local engineering during the past year is the completion of the new channel of the Yarra. This will permit vessels of the largest tonnage to reach the city, instead of remaining at Sandridge or Williamstown, and is the first step toward making Melbourne one of the finest ports in the world. The vast area of low-lying ground, free from rock or other impediment to excavation, is admirably suited for the construction of docks and warehouses, with ample road and railway communication. The enlargement and shortening of the channel of the Yarra, and the construction of the new bridges, which are already commenced, will greatly reduce the rise of the water in time of flood, and so prevent the recurrence of the damage that has been done in past years.

There is one question of the gravest importance which has not yet been dealt with, and that is the sewerage of the city. With the rapid increase of the population and extension of manufactures, the quantity of foul fluid produced is ever augmenting. At present this finds its way from each part of the city and suburbs by the shortest course into the Yarra or its tributaries. The summer flow of the river is insufficient to dilute it, and render it inoffensive; the tidal scour is too feeble to render any real assistance, and so the Yarra is daily becoming a greater nuisance and a graver menace to public health. The valley of the Moonee Ponds Creek is even worse, owing to the almost total cessation of that stream during a large part of the year. What we urgently need, and must have, no matter what the cost, is a complete system of intercepting sewers to carry all foul water away, independently of the Yarra and its tributaries, which would thus be restored to their original purity. Adelaide has its system of sewers, which are pronounced a complete success; the work is well advanced in Sydney; while Melbourne alone, though the largest, and claiming to be the most enterprising, of the Australian capitals, has yet to take the first step in this vitally important matter.

The new aqueduct whereby the water of the Watts River will be brought into Melbourne has been commenced, and in connection therewith wrought-iron pipes are being used instead of cast-iron—an innovation of American origin, and calculated to effect a large reduction in the cost of the work. This aqueduct will bring in an enormous supply of excellent water; but as it will cut off one of the most important tributaries of the Yarra, and so reduce the amount of water available for flushing the filth of Melbourne away, its inception is a strong additional reason why the construction of the intercepting sewers should be no longer delayed.

The completion of the railway from Melbourne to Adelaide marks a new era in intercolonial communication; and as the northern system of New South Wales will very shortly connect with the Queensland lines, a continuous journey by train from Adelaide, *viâ* Melbourne and Sydney, to Brisbane will soon be possible. There is, however, a gap between the southern and northern railways of New South Wales at the Hawkesbury River. This is about to be crossed by a bridge of gigantic size, constructed by an American manufacturing company, and which will in depth of foundations excel every other bridge in existence. This bridge is of highly scientific design, and will constitute a great advance upon the present structures on colonial railways.

The application of accumulators, or storage batteries, to electric lighting is just now under test on a considerable scale in this city, and so far promises well. Much is hoped from a system intended to render the supply of electricity as steady and as convenient as that of gas.

An inquiry has recently been held as to the possibility of placing the ever-increasing mass of telephone wires underground, but with a negative result. Were our streets provided with a complete system of underground subways, or tunnels, large enough for the workmen to traverse, with branches into all the more important banks, public buildings, and suites of offices, the desired end might be accomplished. In the absence of this costly provision, all that we can hope for is some mitigation of the evil by the use of cables containing many conductors, and possibly placed underground, the final distribution being made by fine and almost invisible wires radiating from ornamental iron pillars placed at intervals along the streets.

In steam machinery there is not much advance. Higher pressures and more expansion are gradually coming in. Most of the new steamboats have three cylinders of different sizes, and the steam, which is at first produced at a pressure of considerably above 100 lbs. per square inch, is utilised successively in each of the three cylinders before it escapes to the condenser. In this way a very large amount of power is obtained from the coal consumed.

The compound system—that is, the system of working the steam [successively through two or more cylinders of increasing size—is universal at sea, but hitherto has not been much employed on land. It is at present, however, being practically tested on locomotives in various parts of the world. Certain peculiarities in the conditions render the application of the system more difficult on railways than on steamboats, but, in spite of this, the results are said to be promising.

The gas-engine, which is, on thermodynamic grounds, a more promising machine than the steam-engine, does not advance as rapidly as was hoped. It is, however, plainly in its infancy, while the steam-engine is in its manhood. We should therefore not be surprised at a large advance being made at any time.

Since the last annual meeting two important lines of cable tramway have come into operation in Melbourne, with satisfactory results. When the lines under construction or proposed are complete we shall possess a more perfect tramway system than any city elsewhere.

THE MELBOURNE UNIVERSITY.

The number of students at the University continues steadily to increase. There have been during the past year no less than 454 students attending lectures, while 530 have signified their intention of presenting themselves at the forthcoming examinations. Of the professional schools, that of medicine is by far the most popular, and the entries for the various medical examinations represent 182 candidates. Larger lecture-rooms are urgently needed, especially on the Arts side, and, it is to be hoped, will soon be provided. Preparations are being made for the establishment of an engineering laboratory on the lines of that at University College, London; and a very powerful testing machine, for investigating the strength and elasticity of materials, is at present being constructed in England, under the supervision of Professor Kennedy, of University College, London. This machine is expected to be ready for use early next year.

Professor M'Coy, an old member and former Vice-President of the Royal Society of Victoria, after thirty years of active and uninterrupted service at the University, has recently left the colony on a brief visit to Europe; and the Chair of Chemistry, vacant through the death of Professor J. D. Kirkland, has been entrusted to Dr. Orme Masson. A professor on Biology is expected to be shortly appointed.

The Museum of Natural History, situated in the University grounds, is suffering greatly from want of sufficient accommodation. The building, which was at first amply large, is now quite inadequate for the rapidly augmenting collection; consequently great numbers of valuable and interesting specimens are placed on the tops of high cases, or are stowed away in dark and inconvenient corners, and in this way the real utility of the institution is considerably impaired. An additional building of at least equal size to the present one is most urgently needed. Among the recent additions to the collection may be noted some most interesting and beautiful birds and insects from New Guinea and the adjoining islands.

In view of the recent discussions as to the reproduction of the platypus, it may be worth mentioning that a very fine group of these curious creatures is to be found in the Museum, and also specimens of alleged platypus eggs.

The Ballarat School of Mines reports a large increase in the number of students. An Astronomical Observatory has been instituted at Mount Pleasant, the whole expense of building and instruments being borne by the Vice-President, Mr. Oddie. The Field Class and Science Society connected with the School have been very active during the year. The sister institution at Sandhurst is similarly flourishing. The classes are well attended, and valuable additions are being made to the Museum. The Meteorological Observatory is in active work, and an Astronomical Observatory is projected.

The Working Men's College, established through the munificence of the Hon. Francis Ormond, has not yet commenced operations. A substantial building has been erected in Latrobe-street, but no definite preparations for actual teaching has yet been made. It is to be hoped that steps will be taken at an early date to arrange the classes. The marked success of the Sydney Technical College is a guarantee that an institution on similar lines in our city would be well appreciated by great numbers of apprentices and workmen.

THE INDUSTRIAL AND TECHNOLOGICAL MUSEUM AND LABORATORIES.

Many new and interesting specimens have been added to the collections, and large collections have been made and forwarded to London to aid in demonstrating the uses to which our native timbers, clays, minerals, &c., may be put.

The process devised in the laboratory for the preservation of fruit, has already established a new and large industry, and our fruits are to be found in the jam factories of all the colonies.

Trials with clays have led to the establishment of terra-cotta works, and in metallurgy a new modification of the Platner chlorine process has been introduced with marked success.

Amongst the more interesting specimens added is a large meteorite, weighing about three-quarters of a ton. It was found recently at Langmerrim, near Frankston, and presented to the Museum by the finder. Though mostly metallic iron, it presents some difference to the well-known Cranbourne meteorites.

The laboratories are attended by twenty-eight students.

THE PUBLIC LIBRARY.

This institution has had its usefulness greatly enhanced during the past year by the completion of a new wing, providing much additional space both for library purposes and for the effective display of numerous art treasures.

THE COLLEGE OF PHARMACY.

During the past year Pharmacy has continued to make steady onward progress. The selection by Professors Attfield and Redwood of a gentleman in England, who has since arrived and assumed the duties of director of the College of Pharmacy, should greatly add to the future progress of the Institution.

The publication of a high-class journal during the past year has also been an event of some importance, and it is gratifying to find that articles of original research, published in the pages of the "Australasian Journal of Pharmacy," have been reprinted in the leading pharmaceutical journals of the world.

With a view of further advancing pharmaceutical education, a conference, which will be attended by delegates from all the colonies, will take place on the 27th, 28th, and 29th October, and from their deliberations we may hope that the best results will follow.

KINDRED SOCIETIES.

The Geographical Society of Australia, as represented by its branches in the various colonies, continues its work. The Victorian branch has, in conjunction with the Royal Society, appointed a committee to consider the question of "Antarctic Exploration." This committee has held several meetings, and is at present in communication with the British Association, the Royal Geographical Society, the Scottish Geographical Society, the Royal Society of Tasmania, and other bodies. The various colonial Governments have shown sympathy with the movement, and the Imperial Government is to be approached on the question. Considering how much has been accomplished in the way of arctic exploration, it is somewhat singular that so little has been done in southern regions. The difficulties do not appear to be particularly great, provided a suitable steam vessel, of sufficiently massive build to endure the shocks of ordinary floating ice, be obtained. The actual distance from the south of Tasmania to the southern continent is not more than would be easily traversed in a week by a steamer of moderate speed. The harvest of scientific results to be reaped by such an expedition would most probably be rich, while substantial advantages of a commercial nature might not improbably be secured.

Exploration in New Guinea is at a standstill at present. The Forbes expedition, to which the Geographical Society contributed £500, has been compelled, through lack of funds, to quit the field. This is to be regretted. On the other hand, the German portion of the island is being opened up, and a fine river, navigable, it is stated, for 400 miles, has been discovered.

The Field Naturalists' Club progresses favourably, the number of members having increased considerably. Very pleasant and profitable excursions into the country are periodically made, resulting in the collection of interesting specimens of various kinds. An exhibition of Victorian wild flowers has been recently held, at which no less than 180 different species of Victorian plants were shown. The club is doing an excellent work in directing the attention of the public, and especially of the young, to the numerous natural objects of beauty and interest with which our colony abounds.

The Microscopical Society continues its meetings as usual, but has but little to report of general interest.

The Historical Society, formed rather more than a year ago, is quietly at work collecting first-hand information bearing on the original settlement and early history of these colonies. From the nature of the case, the work is not likely to attract much public attention, but it is not on that account any the less valuable. The future historian of our continent will find his toils much reduced, and the reliability of his narration greatly enhanced through such work being undertaken at a time when some of the pioneers have not yet passed off the stage, and the relics of early settlement have not yet been all destroyed to make way for the march of modern improvement.

A Philosophical Society has just come into existence under favourable auspices. Whether it will succeed in throwing any new light on the problems that have baffled the human intellect since the days of the ancient Greeks, time alone can tell. In any case, the mere existence of such a body is a hopeful sign in a country where there are so many temptations to direct one's attention too exclusively to practical and material considerations.

It will thus be seen that there has been no abatement of activity in scientific matters during the past year, and that proposals have been made, and schemes brought under consideration, which promise a wider scope and more advantageous conditions for scientific work than have existed heretofore.

At the same time, when we consider the large and increasing population of our colony, and especially of its metropolis, we cannot fail to be struck with the comparatively small number of real earnest workers in the various branches of science. With our wealth, our educational advantages, our comparatively short hours of labour, we ought not to rest satisfied with the present state of things. The bulk of the labour is done after all by a few, and these in many cases men past the meridian of life. We look anxiously for the scientists of the future, with youth, strength, and enthusiasm in the good work, to appear on the stage, and lift at any rate a portion of the load from the shoulders of those who for many years have borne the heat and burden of the day.

TRANSACTIONS.

Art. I.—*The Oceanic Languages Shemitic:*

The Personal Pronouns.

By Rev. D. Macdonald, Fate, Havannah Harbour, New Hebrides.

[Read 11th March, 1886.]

1. "The vast and perfectly well-developed family, the Malay-Polynesian . . . is divided (Friedrich Müller) into three great branches—1. The Malayan, filling on the one hand the great islands nearest to Asia, and on the other hand the Philippine and Ladrone groups; 2. The Polynesian, in most of the smaller groups, with New Zealand and Madagascar; 3. The Melanesian, of the Fijian and other Archipelagoes off the north-eastern corner of Australia." Thus Whitney, "Life and Growth of Language," p. 242 (International Scientific Series, London, 1880). I should prefer calling this family the Polynesian, but as that name has already been used in a more limited sense, it may be more convenient to call it the Oceanic, at any rate for the present. As to the subdivision of the family into these three groups, it seems better to take the Malagasy as a separate or fourth group, for there are many dialects of it, and it is at least as much akin to the Malayan or the Melanesian as to the "Polynesian." On the whole it is most akin to the Melanesian. This latter name is not unobjectionable, and Papuan is preferable. "Polynesian," as here limited to the few scattered islands stretching from New Zealand to Hawaiia, is totally indefensible; those islanders who speak this group of dialects are far fewer than either the Papuans, Malagasy, or Malayans, and it is misleading and inconvenient to call them, the fewest of the Oceanians or Polynesians, exclusively by this name. We shall use instead, for the present at least, the name Maori-Hawaiian. Thus we have —Family, Oceanic or Polynesian; sub-groups, 1. Malagasy, 2. Malayan, 3. Papuan, and 4. Maori-Hawaiian.

2. As to the four Oceanic groups, I may mention that I shall take the Ankova dialect of Madagascar, the Malay of Marsden and Crawford, the Fatese and the Samoan to represent the Malagasy, Malayan, Papuan, and Maori-Hawaiian respectively, making use, of course, of the kindred dialects. The authorities, grammars, and dictionaries for

the Malagasy, Malayan, and Maori-Hawaiian groups are numerous and well known, and it is to them I am indebted for my facts. The fourth group, the Papuan, is not so well represented in grammars and dictionaries (indeed, only two dialects, the Fijian and Aneiteumese, can as yet boast of such works), but to make up for that it is the group with which I am personally and very intimately, by years of long and daily study and use, acquainted. I have chosen the Fatese simply because I know it best. Much the best general works on the Papuan languages known to me are the two volumes of Gabelentz, "Die Melanenischen Sprache," Leipzig, 1860 and 1873. In the second of these volumes will be found a very brief notice of (a dialect of) Fatese spoken on the south side of Fate ("Die Sprache der Insil Fate"), and a longer notice of another dialect of Fatese spoken on a neighbouring island ("Die Sesake-Sprache auf Api"). For the islands in the New Hebrides on which there are mission stations, I am indebted to the missionaries for information; and for the others, and some dialects even of these, I have nothing but the knowledge obtained at first hand from the native speakers of these dialects themselves.

3. *O* in Malagasy is sounded as *u* in the other dialects; *g* in Fatese and Samoan is sounded as *ng* in Malay and Malagasy. The inverted comma in Samoan represents "a sound something between h and k."

4. The Oceanic pronouns are found, *e.g.*, in Fatese (see Gabelentz on the "Sesake," as above) as separately used, the separate pronoun; as used only with a verb, forming the personal inflection of the verb, the verbal pronoun; as following and being the object of a verb, the verbal suffix; and as following a noun and expressing the genitive or possessive, the nominal suffix. The Oceanic pronoun has no inflection of gender or of case, but it has an inflexion of number. The Fatese, for instance, and Samoan have a singular, a dual, and a plural.

5. The Oceanic pronouns I, Thou, and He are in their simplest form—

I *ku*
Thou, *ka*, *ta* (*k* and *t* interchanged)
He *i* or *e*

The last is also demonstrative, in Fatese, meaning *this*. These pronouns sporadically are found used in this naked form in Oceanic, but generally they are in forms much disguised by phonetic change or contraction, and by the addition of demonstratives or emphatic particles usually prefixed but sometimes also suffixed. Often, too, the plural is found in use for the singular, and in many dialects the singular of the second person as simple *Thou* is never used, but only the plural *You*.

6. There are two plural endings by which these pronouns become We, You, and They, *m* and *u*, thus—

I *ku* (Malay)		We *kum* (Eromanga)	
Thou *ka*		You *kam* (Api)	
	Malay	We *kami*,	You *kamu*
	Fate	We *agam*,	You *kumu*

The third person originally was He *i*, They *im*, but *im* as actually found in use has usually dropped the *i*, and has some emphatic suffix to the *m*—Ambrym *mu*, They. In Maori it is found in the plural interrogative *wai ma*? Who-they? (*wa-i*, singular, Who-he? and *wa-ima*, plural, Who-they?) So Fate sē? (for *se-i*) sing., and *semai*? and *semani*? plural, in which final *i* and *ni* are emphatic.

7. It is rare, however, to find this pronoun in Oceanic used for They. There is instead almost universal a word (properly These, or Those), which we find in Aneiteum as *ara*, Tanna as *iraha*, *ilia*, and *ila*, Eromanga as *irora*, lēl, and *yoril*, in Maori-Hawaiian as *la* and *ra*, in Malagasy in *izareo*, and in Tagala in *sila* (*sia* He, *sila* They): Fate, *nara*. These are all one and the same, the *l* and the *r* being mere phonetic variations of each other.

8. The Fatese uses the plural ending *m* with the separate pronouns, § 6, and the plural ending *u* with the verbal pronouns, thus—

I	*a* (for *aku* or *ku*)	We	*au*
Thou	(*ka*, Api)	You	*ku*
He	*i* or *e*	They	*iu* or *eu*

Fatese *ku*, You, is used also for Thou. These are the only two numeral inflections of the plural of the Oceanic pronouns. The *m* inflection has been completely lost in the Ankova dialect of Malagasy, where the *u* also has become *y* (or short *u*) for the most part. There can, I think, be little question that the *u* is a mere phonetic variation of the *m*.

9. The Inclusive.

This is a combination of the pronouns of the first and second persons. Thus Malay and Tagala *kita*, Fate *akit*, Fotuna (Maori-Hawaiian) *akitea* or *akita*, is *ki* (for *ku*), I, and *ta*, Thou. Malagasy *kia* (in *isikia*) is for (*kiha*) *kika ki* I, as in Malay, and *ka* Thou; and it is to be compared with Bauro (Papuan) *gia*.

This syntactical combination, which we shall call by the usual name of the Inclusive, is found much disguised and corrupted in various dialects, and either of its component elements (I or Thou) may be found in a particular dialect *alone*, representing the whole. In Fatese the second number (Thou) is used *alone*, but only as the verbal pronoun; and this gives us, as will be seen, a form of the pronoun of the second person in the three numbers—singular, dual, and plural.

10. The Dual.

The dual ending is *a*. It is found in Fatese, not in the separate, but only in the verbal pronoun, thus—

Third plural (South dialect)	*ru*, They
Third dual	*ra*, They two

And so exactly (see § 9).

Inclusive plural	*tu*
Inclusive dual	*ta*

The Samoan dual is—

Third dual *la*
Inclusive dual *ta*, as the Fatese
First dual *ma*, wanting in Fatese

The *a* is a true dual inflection or ending in these Fatese verbal pronouns: the *a* of the Fatese and Malagasy numeral *rua*, Samoan *lua*, Malay *dua*, Tongan *ua*, 2, is this same *a*.

Most of the Oceanic dialects have this dual ending only as found in this numeral.

11. Hitherto we have been occupied with the inflexional endings of the Oceanic pronoun, whose original or simple form we have also seen. It is seldom, however, we find the pronoun in its simple form. Thus the pronoun of the first person *ku* is found in Malay as *aku*, Malagasy as *aho* and *izaho*, in Samoan as *a'u*, and in Fate as *au* and *a*. The most common and influential demonstrative found attached to *ku* is *n* (as *ana*, *in*, *na*, *ni*, &c.)—thus Fate *nau* (for *naku*), verbal suffix *ki nau*, separate pronoun; verbal pronoun *a* (for *aku*), nominal suffix *gu* (for *ku*, Malay *ku*, Malagasy *ko*). In one dialect of Fatese the verbal pronoun is *ni* (for *naku*), and the nominal suffix *ga* (for *ku*). Compare the Papuan generally in Gabelentz. Thus we see that

the real kernel of the pronoun (*ku*) sometimes almost disappears, and is found represented either by a pure contraction of itself alone as *a*, I, or a mixed contraction of itself and prefixed demonstrative *n*, as *ni*, I. Still keeping to the Fatese, we find for the plural in one dialect *nikam*, We (for *niku* and *m*), in another *ki nami* (for *ki naku* and *m*), in a third *agam* (for *aku* and *m*), and in a fourth *komam* (*koma*, the plural, and *m* emphatic). In the first two *n* appears, but not in the last two. Exactly so in Malagasy, where, however, the *n* appears only in the plural, thus separate pronoun, *izahay*, We (*ahay* for *aku*, and *u* plural ending), and nominal suffix *nay* (for *naku* and *u*, as Fate *nami* is for *naku* and *m*).

12. Relationship.

In affirming that the Oceanic pronoun is Shemitic, I use the words as they are used when it is said that the Arabic is Shemitic, by which, of course, it is not meant that the Arabic is derived from the Hebrew or Phenician, but from the same mother-tongue as the Hebrew and Phenician.

13. First, then, the simple or original Oceanic pronouns given above, § 5, of the first, second, and third persons, are purely Shemitic. Thus (see the standard grammars—*Hebrew, Arabic, Ethiopic, Assyrian*, especially Dillmann, "Grammatik der Ethiopische Sprache," § 65) in the Shemitic—

I is *ku* or *ki* (*u* and *i* interchanged)
Thou *ta*, *ka* (*t* and *k* interchanged)
He is *u* (*i* in verbal pronoun)
(She is *i*)

The last (*u*) alone is apparently slightly differently pronounced in Oceanic, as *i* or *e* or *y*, as in English *county;* but see this accounted for below, § 24, note *a*.

Again, the *m* and *u* plural endings or inflections of these Oceanic pronouns, §§ 6, 8, are purely Shemitic. Thus (see Green, *Hebrew Grammar*) there was originally a Hebrew plural of the first person.

We *anum* (but now found only as *anu*)
Ye *atem*, Hebrew (*kemu*, Eth. verbal pronoun)
They *hum*, *humu*, Arabic

Compare with these—

We *anam*, Espiritu Santo (cf. Fate above)
Ye *itama*, Tanna, Weasisi dialect
They *eovu*, Anudha, *mu* Ambrym

And again—

1. We *nu,* Hebrew verbal pronoun, and nominal suffix
2. Ye *tu,* Mod. Arabic verbal pronoun
3. They *u* (for *iu*) Heb. verbal pronoun (compare *i-u,* with imperfect)

Compare with these—

1. *nay* Malagasy nominal suffix
2. *tu* Fate verbal pronoun, §§ 9, 10
3. *iu* Fate verbal pronoun, and *u* (for *iu*), Paama verbal pronoun

14. These *m* and *u* plural endings are, both in Oceanic and Shemitic, in reality one and the same, the *u* being a mere phonetic variation of the *m.* In Fatese *m,* especially final *m,* is often changed into *u.* As to the modern Arabic *entu,* Ye (for *entum*), compare Aneiteum separate pronoun *aijaua,* Ye (for *aitaua,* for *aitama,* Tanna *itama,* Api *tau*), verbal suffix *caua* (for *cama*), Mod. Arabic *kum.* Note also in these examples the interchange of *t* and *k.*

15. The Dual ending *a.*

As to the Shemitic (see standard grammars), the ancient Arabic is the only dialect that has retained the dual of the separate and suffix pronoun of both the second and third persons (the Sabaean retaining that of the latter only), while only the Sabaean and Assyrian (third person only), along with the Arabic (second and third persons only), have retained it in the verbal pronoun. The Ethiopic has lost every trace of it, except what remains in the ending of one word, the numeral 2; and the Syriac retains a trace of it in the endings of three words only—the words *two, two hundred,* and *Egypt.*

The Assyrian dual ending is *a.* In the Assyrian *isaccinaa,* They two place, *i–a* is the verbal pronoun; so in the Arabic *iqtulaa, i–a* is the verbal pronoun dual, They two; and in the Arabic *taktulaa, ta–a* is the verbal pronoun, Ye two. Now the Fatese has the inflectional dual of the verbal pronouns of the second and third persons only, like the Arabic, and that of the second person is only retained in the inclusive *ta* (Samoan *ta*), §§ 9, 10, which has the very same elements as this Arabic *ta-a.* That of the third person *ra* (Samoan *la*), They two, has the dual ending attached to the demonstrative *r,* just as in the Arabic *qatalta*, the final *ta*, They two (fem.), has it attached to the (feminine) demonstrative *t*.

The Samoan has retained in *ma*, We two, the dual of the first person also.

16. The Arabic separate pronoun has the dual thus—

Third person *hum*, plural; *huma*, dual
Second person *antum*, plural; *antuma*, dual

In the Mallicollan dialect in Gabelentz the dual inclusive is *drivan*, having the same meaning and use as the Fatese *ta*; the Mallicollo *dr* is the Fatese *t* representing the pronoun of the second person, as already shown. Therefore *van* = two = dual ending; "*van* für zwei scheint aus dem zahlwort *ua* abgeleitel," says Gabelentz, nearly hitting the exact truth. Now, as we compared Fatese *ta* with Arabic *ta-a*, in *taqtulaa*, so we must compare Mallicollan *drivan* (*tivan*) with Arabic *tuma*, Ye two, in *qataltuma* (*m* and *v* interchanged). Thus *drivan* is to be compared also with the well-known Maori-Hawaiian *taua*, just as Fate *ta* with Samoan *ta*. If this is correct, then *ua*, the numeral 2, in Mallicollan and Tongan, is to be compared with the Arabic *huma* or *homa*, They two: Fate *rua*, 2, is this *ua* with demonstrative *r* prefixed (as in the verbal pronoun *ra*, They two, and so Malagasy *rua*, Samoan *lua*, Malay *dua*). That this is, in fact, the true origin of the Oceanic numeral 2 is, I think, certain: further discussion of that particular point will come properly under the Numerals. But it may be said here that just as we find *–va–* for *ua* in this Mallicollan pronoun, so in the Tagala numeral 2, as given by Forster, it is *va*, for he gives it as "*dalava* or dalova" (compare Ceram *darua*). It goes without saying that *ua* is from *va*, not *va* from *ua*, and that *va* is the older form. The word *ua* is pronounced in Oceanic, and might have been written, as it sometimes is, *wa*. The change of *m* to *v*, *w*, and *u* is one very common in Shemitic, and especially in Oceanic.

17. The separate pronoun, the verbal pronoun, the verbal suffix and nominal suffix are all used in Shemitic exactly as in Oceanic. But the verbal pronoun in Oceanic has only one form for all tenses, and is never divided, as in the Shemitic imperfect. The essential thing is that it is a short representative of the separate pronoun, having the same component elements, and denoting in the same way the person and number of the verb (without which it cannot be used), as in the ancient Shemitic.

18. Comparison. The Pronoun of the First Person.

Separate Pronoun, Singular.

Aneiteum, *ainyak*	Phenician, *anek*
Fate, *kinau* (for *ki naku*)	Assyrian, *anacu*
Api, *nangka* (*naka*)	„ *anku*
Bauro, *inau* (*inaku*)	Hebrew, *anoki*
Esp. Santo, *nau* (*naku*)	
Malay, *aku*	
Samoan, *'o a'u* (*ko aku*)	
Malagasy, *izaho* (*iz ako*)	
Lifu, *eni*	Hebrew, *ani* (anoki)
Ambrym, *ni*	Ethiopic, *ana* (anaku)
Mallicollo, *kena* (*k ena*)	Arabic, *ana* (for *anaku*)

Verbal Pronoun.

Esp. Santo, *ka*	Ethiopic, *ku*
Aneiteum, *ek*	
Mahaga, *ku* (cf. Malay *ku*)	
Tongan, *te*	Hebrew, *ti* (*t* for *k*)
Fate, *a*	Arabic, &c., *a*
Tanna, *ya*	
Mallicollo, *ni*	Mod. Syriac, *in*

Nominal Suffix.

Fate, *gu*	
Malay, *ku*	
Malagasy, *ko*	
Esp. Santo, *u*	Hebrew, &c., *i*
Laman (off Api), *o*	Assyrian, *ya*, *a*, and *i*

19. Plural.

Separate Pronoun.

Esp. Santo, *anam*	Hebrew, *anu* (*anum*)
Fate, *kinami*	
Fate, *nigami* (*nikumi*)	
Malay, *kami*	
Malagasy, *iz-ahay* (*aku-u*)	
Lifu, *nihunie*	Arabic, *nahhnu*
Lifu, *eahuni*	Mod. Syriac, *ahhni*
Mallicollo, *kon* (riti) (dialect of Sasoon Bay, east side)	

Verbal Pronoun.

Mallicollo (Port Sandwich), *ne* (ti)	Hebrew, *ne*
Api (Mission Station), *ni*	Arabic, *na*
	Assyrian, *ni*
Fate, *au* (aku-u)	Mod. Syriac, *ak*, *ik*
Mahaga, *ki* (ti)	

Nominal Suffix.

Malagasy, *nay*	Assyrian, *nu*, and *ni*
Fate, *nami*	Arabic, *na*
	Syriac, *n*.

20. The Pronoun of the Second Person.

Separate Pronoun, Singular.

(Note.—The plural used *often* for singular.)

Api, *tau* (*ta*, and pl. ending *u*)	Hebrew, *atta* (for *an-ta*)
Yengen, *do* (for *dau*)	
New Caledonia, *to* (for *tau*) and (*k* for *t*)	
Tagala, *ikau*	Hebrew, &c., old form *akka* (for an-*ka*)
Malay, *angkau*	
Mall., *aingka* (for *ainka*)	(See Gesenius, *Gram.*)
Eromangan, *kik*	Harari, *akhakh*
Fate, *ag* (*ak*)	
Aneiteum, *aiek*	
Tanna, *ik*	Tigre, *ika*
Negrito, St. Matheo, *hica*	Tigre, *niska* (is *nisu* This, *ka* Thou)
Lubu (aborigines of Sumatra), *aka*	

For *ta* (*t* for *k*), Thou, in Oceanic, see Inclusives below.

The Verbal Pronoun.

Api, *ka* (cf. Malay, *kau*, *ka-u*)	Ethiopic, *ka*
	Sabaean, *ka*
Mallicollo, *ke*	
Fate, *ku* (plural for singular)	

The Verbal Suffix.

Fate, *k*	Heb., Arabic, Ethiopic, Assyrian, Syriac, *k*, *ka*
Mall., *k*	
Paama, *k*	
Aneiteum, *euc*	Mod. Syriac, *uk*
Fate, ko (for *kau*; cf. Malay, *kau*) is plural for singular	

I give the following in this person alone, and in the singular:—

The Emphatic Possessive.

Eromangan, *arika*	Ethiopic, *eliaka*
Samoan, *lau* (laka-u)	
Eromangan, *eteko*	Mod. Syriac, *diuk*
Maori, *tau* (taka-u)	
Tanna, *seik*	Ethiopic, *ziaka*
Samoan, *sau* (saka-u)	

All these prefixes are originally demonstratives, and all these words mean *this* or *what* (is) *of thee, thine.*

The Suffix with a Preposition.

Eromangan, *buka,* To thee	Hebrew, *beka,* To thee

21. The Plural, Ye.

(Note.—The majority of Oceanic dialects have the plural with ending *u* (*tau, kau, to, ko*) in use for the singular (cf. English *you*), and the plural with ending *m* in use for the plural. The Malagasy having ceased to retain the *m*, suffixes *reo* (these), to distinguish the plural used for *ye* from that used for *you.*)

The Separate Pronoun.

Tanna (Weasisi), *itama*, or *ituma*	Hebrew, *attem*
	Arabic, *antum*
Aneiteum, aijaua	Mod. Arabic, *antu*
Api, *tau*	
And *k* for *t*	
Malay, *kamu*	Ethiopic, *antemu*
Fate, *kumu*	(Hebrew, *attem*)
Fate, *akam*	
Fate, *nikam*	
Negrito, St. Matheo, *hicamu*	

Eromangan, *kimi*
Fotunese, *akaua*
Tagala, *kayu*
Fate, *egū*
Duauru, *inggu*

Verbal Pronoun.

Fate, *ku*	Heb. &c., *t-u*
Fate, *tu* (in Inclusive)	Mod. Arabic, *tu*
Malay, *kamu* (Sep. Pron.)	Eth., *kemu*
	Heb., *tem*

Nominal Suffix.

Malay, *kamu*	Ethiopic, *kemu*
Fate, *kam*	Heb., *kem*
(Often contracted in Malay, Fate, &c., to *mu*, *ma*, *m*, and used for singular like English *your*)	Arb., *kum*

22. The Inclusive.

Malay, *kita*, (*ki* I, *ta* Thou)	For *ki* I, and *ta* (*ka*), Thou, see §§ 18, 20
Fate, *akit*	
Fotuna, *akita*	
Malagasy, isikia (is-ikia, see § 9)	
Bauro, gia	
Ambrym, *kenga* (for *keka*)	

This combination is found as in all languages so in the Shemitic. See Caussin de Percival, *Grammaire Arabe Vulgaire*, § 223, who gives these two forms of it: "*ana ou ente*" and "*ana ou eyyak*," I and Thou—that is, *ana* I, *ou* (pronounced *u*), and *ente* (ent*a*) or *eyyak* (eyya*k*), Thou. Now note (*a*) that the *and* is vulgarly left out in Oceanic; and (*b*) that *ente* or *enta* as it drops the *n*, for instance, in Hebrew, so in Oceanic this *nt* is *t*. The *n* is mere emphatic prefixed to *t* the pronoun.

Santo, nitsi, inti	Arabic, *ana* (*ou en*)*te*
Aneiteum, *inta* (verbal pronoun)	
Mall., *anre* (for *ante*), as Fate dialect, *igira* for *igita*	For *ni*, I, see § 18

Lifu, *nisha* (for *nita*, as
Eromangan *kos*, Tanna
kita)

In Malay, Maori-Hawaiian, and Papuan *ta* is generally used for Thou in this combination, and not *ka*; but Hawaiian does not distinguish between *t* and *k*, and has only one letter (*k*) for both.

Most of the Maori-Hawaiian dialects have lost the first member of the phrase (*ki* or *ni* I), and have only the last *ta* (Hawaiian *ka*) Thou. Fate uses only this last as the verbal pronoun, thus

Dual	*ta* (literally, *Ye two*)
So Samoan	*ta*
Plural	*tu* (literally *Ye*),
So Tongan	*tau*

23. The Pronoun of the Third Person.

Separate Pronoun, Singular.

Malagasy, *izy*	Assyrian, *su*
Malay, *iya*	Hebrew, *hia* (fem.)
Tongan, *aia*	*hua* (mas.)
Fate, *nai*	
Samoan, *'o ia*	
Fate, *enea*	Talmud, *enhu*
Malay, inya	
Tagala, *sia*	Assyrian, *si* (fem.)
Negrito, Umiray, *edu*	Ethiopic, *uĕtu*
New Caledonia, *iet*	
Aneiteum, *aien*	Mod. Syr., *aon*
Tanna, *in*	,, *ain* (fem.)

The Verbal Pronoun.

Fate, &c., *i* or *e*	Heb., &c., *i*
Aneiteum, *et*	Arabic, *t* (fem.)
Mallicollo, *ni*, or *ne*	Syriac, *ne*

The Verbal Suffix.

Fate, *i*, *e*, or *ia*	Heb., &c., *u*
	Chald., *eh*
	Syr., *i*
Malay, *nia*	Heb., *ennu*
Fate, *na*, *nia*	Heb., *na*

Malagasy, *azy*	Assyrian, *assu*
Fate, *sia*	„ *assi* (fem.)
Fate, *s*	„ *s*

24. The Plural.

The Separate Pronoun.

Ambrym, *mu*	Arabic, *humu*, *hum*
Ambrym (dialect in Gabelentz), *vu* (in *mu ri*, *vu ru*, They two)	
Anudha, *eovu* and *eovu aki*	
Mahaga, *maria* (ma ria)	
Malay, *marika* (ma rika)	
Maori, wa-ima ? (§ 6)	Heb., *hem*
Fate (§ 6) *s-emai*, *s-emani* ?	Ch., *himo*, *himon*

For the commonest word for They in Oceanic, see § 7 (These, those).

Eromanga, *yoril*, *lēl*, *irora*	Arabic, *ola* and *olalik*. (C' *elola*, " originally a demonstrative pronoun")
Tanna, *ila*, *ilia*, *iraha*	Hebrew, *eleh*
Aneiteum, *ara*	
Tagala, *sila*	
Fate, *nara*	
Api, *nala*	
Paama, *keila*	
Mallicollo, *kara*	
Malagasy, *izareo*	Ethiopic, *elu*
Samoan, *latou*	
Maori, *ratou*	
Tongan, *nau*	Mod. Syriac, *ani*
Duauru, *ne*	

NOTES ON THE PRONOUN OF THE THIRD PERSON.

a. The Oceanic singular common has for its characteristic letter *i*, like the ancient Shemitic feminine, and not *u*, like the ancient masculine. This is exactly paralleled by the Mod. Syriac *ani*, which, though common (m. and f.), has the *i* of the ancient fem., and not the *u* of the ancient masculine —thus *ani*, They, Mod. Syriac, common, derived or corrupted from ancient Syriac { *anun*, m. / *anin*, f. } These, those.

b. But while the Oceanic has dropped or lost the inflection of gender in the personal pronouns of both singular and plural, the Modern Syriac has dropped or lost it only in those of the plural.

c. *Ani* means Those as well as They.

d. *Ani*, though plural, is sometimes used for the singular in Mod. Syriac.

So Malay *nia*, Malagasy *ny*, are both plural and singular as nominal suffix.

25. The Verbal Pronoun.

Fate dual	*ra*	§§ 8, 10, 13
„ plural	*ru*	
Samoan dual	*la*	
Tongan plural	*nau*	

The Verbal Suffix

(in most dialects calls for no remark, but the following is very remarkable)

Api, *tomiako* (cf. singular *teteako*), *ako* like *aki* in Anudha *eovu aki* (see Separate Pronoun) is emphatic.

Api, *tomi* (ako)	Tigre, *tome*
	Eth., *homu* (for *tomu*); Dillm., Gr., § 149)

26. Briefly and inadequately as this extensive subject of the Pronouns is handled in the foregoing, it is much more full than the section on the same subject in a former paper (1883), which also, as may be noted, is hereby corrected in certain particulars.

II. THE NUMERALS.

(With an Appendix on the Australian Numerals.)

§ 1. The Oceanic numerals cited in the following may nearly all be found in the lists of Crawford ("Dissertation"), Latham ("Comparative Philology"), H. Gabelentz ("Die Melanenischen Sprachen"), and the "Erster Nachtrag" to that work, of G. Gabelentz and Meyer (Leipzig, 1882), Wallace ("Malay Archipelago"), and Turner ("Samoa," 1884). The few here printed for the first time belong exclusively to the New Hebrides, and are of purely dialectical value.

§ 2. A glance at the numerals of these lists (I omitted to mention those in the "Appendix" to *Cook's Voyages*) shows that there is sometimes attached to them, prefixed or postfixed, or both, the following demonstratives as articles or emphatics:—

1. *l*, as in Samoan *lua* (Tongan *ua*), 2, and Samoan *lima* (Redscar Bay *ima*, Tongan (Forster) *neema*, Pelew *aim*), 5. Compare Mangarei *lotitu, lopah*, 3, 4. This *l* is changed into *r*, as in Fate *rua*, 2, Maori *rima*, 5, and *d*, as in Malay *duwa*, 2, and Malagasy *dimy*, 5.

2. *n*, as Abtiago (Ceram) *entol, enhata, enlima*, and, suffixed, Bouton (Celebes) *taruono, patanu, limanu*, 3, 4, 5. Malagasy *enina*, Bugis *onong* (*n* to *ng*), 6, Malay *sambilan*, Sumatra *sekurung*, Java *sanga*, 9.

3. *m*, Espiritu Santo *mokes, morua, morolu, motar, molima*, 1, 2, 3, 4, 5. Tidore *malofo*, 2, Celebes *mopuroh*, Salibabo *mapuroh*, 10.

Sometimes changed to *p*, *b*, and *v*, *He* and *We*. Guebe *piffat, pileme*, Marquesas *bo ha, bo heema*, 4, 5. Isle of Pines *vo* (for *v-ua*), *veti*, 2, 3, as Duauru *bo, beti, beu*, 2, 3, 4. Yengen *heluk, nimweluk*, 2, 7.

Suffixed we find it in—

Umar	*kotim*	1
"	*etirom*	3
New Ireland	*balam*	4
Malay	*anam*	6
Arru	*dubem*	7
Tagala	*siyam*	9

and changed to *p*, *v*, and *u* in Admiralty Islands *huap*, 2, Princess Island *gunnap*, Santo *merav*, 6, Sanguir *kasiow*, i.e., *kasiau*, for *kasiam*, 9.

4. *k*, Sanguir *kopah, kasiow, kapuroh*, 4, 9, 10. Sula *gahū, gariha, gatasia*, 2, 4, 9.

Postfixed we find it in Yengen *heluk*, Madagascar *rica*, 2, Malay *tiga*, Aneiteum *eseik*, 3, Mafur *fiak*, 4, *fiek*, 7, Arago (New Guinea) *sik*, 7, Karon *mik*, 5, New Ireland *suok*, 9, New Britain *tigai*, New Guinea (Forrest) *tiak*, 4.

5. *s*, and *t* (*d*), Tagala *dalova, tatlo*, 2, 3; Salibabo *tetalo, delima*, 3, 5; Malay *tuju, delapan*, 7, 8, and *salapan, sambilan, sapuluh*, 8, 9, 10; Papuan (Forrest) *serou, siore*, 2, 9; Madagascar *sidda, sivy*, 7, 9; Sumatra *seewah*, Philippines, *siam*, 9.

Postfixed we find it in Sirang *delapante, sambilante*, 8, 9; Aneiteum, *ohwat*, 2; Salawatti *fiet*, 7; Tandia *roesi, toeroesi, attesi*, 2, 3, 4.

6. *a, o, e, i*, Pelew *aim*, 5; Otaheite *a eeva*, 9; Madagascar *isse, essa, eser*, Papuan of New Guinea *oser*, Arago *ossa*, Waigyou *ossa*, and *sai*, 1.

7. To be noted in the above is the use of what may be called the compound article, as Santo *morua*, Tidore *malofo*, 2; Tagala *dalova*, Ceram *darua*, 2; Santo *molima*, Salibabo *delima*, 5.

8. Full discussion of these articles must be reserved till the Demonstratives come to be specially treated. Meantime it may be observed that they are all found in Oceanic used as articles with other nouns, as well as with the numerals: for instance, the first, *l*, is the common article in Samoan; the second, *n*, is in like manner the common article in Malagasy, Fatese, and the New Hebrides (Papuan) generally. And it may be said that it is certain that they are simply demonstratives originally meaning "this." Thus in Fatese alone (in dialects) we find *n, k, s*, and *i* (*e*) used as demonstratives, *fatu in, fatu ke, fatu se, fatu i* (or *e*) all meaning "stone this," or, as we say in English, "this stone;" also *l* as *r* in *erai*, "this" (in one dialect), and even *m* is used as an article (before names of men), and as a final emphatic which is sometimes changed to *b, f*, and *u*. In Malagasy *ra* (for *la*) is used as an article before names of persons, and *ireo* (for *ileo*) is "these," *iroa*, "that," and we have also the *k* in *irikitra, irokatra*, "that." Compare Malay *iki* and *ini*, Malagasy *iny, itsy*, and *izao*, Samoan *sia*, "this," and Malay *itu*, "that, he, the," Malagasy *ity*, "this," and Eromangan *imo*, "this."

On the Shemitic demonstratives *l, n, t, s* (*d, z*), *k*, and *a* (*ha*), see Dillmann, *Eth. Gram.*, § 62. For the Arabic article *l*, South Arabian *m*, see Wright, *Arab. Gram.* I. § 345. For Assyrian *ammu*, and *ma*, "this," see Sayce, *Assy. Gram.*, p. 60. These Oceanic and Shemitic demonstratives are held to be the same, but this is not the place for discussing that. It is sufficient here to observe that in the numerals compared, in the following, on both sides, they will be seen so far as used to be similarly used. For example, with the above final *m* emphatic compare the (Assyrian and) Sabaean "mimation" or final *m* emphatic.

§ 3. In what follows all the Oceanic numerals compared with each other, and all the Shemitic with which they are compared are regarded on sufficient grounds as originally the same. Their present differences are accounted for by—1, phonetic change and decay; 2, the attachment, or not, to them in different dialects of the different demonstratives in § 2, in some prefixed, in some postfixed, and in some both, which demonstratives themselves both suffer and cause phonetic change and decay; and 3, these Oceanic numerals having been reduced to writing by Europeans, allowance has to be made for difference of ear, and of nationality (as affecting the alphabet) of the writer. Also in what follows *Malagasy* means the Ankova dialect, Madagascar *any* dialect in the island, as Sumatra *any* dialect in Sumatra, and so with other names of islands.

§ 4. The first five numerals in the four branches of the Oceanic family (for which see "The Personal Pronouns," § 1) may be thus given:—

	Malagasy.	Malay.	Papuan (Fatese).	Maori-Hawaiian. (Samoan).
1	isa, iray, iraika	sa, asa, satu	sikei	tasi
2	roa	duwa	rua	lua
3	telo	tiga	tolu	tolu
4	efatra	ampat	bāte	fa
5	dimy	lima	lima	lima

We shall take these in order:—

1. The numeral 1 in Oceanic is in Sanguir *ku*, New Ireland *kai*, New Guinea *keteh*, Anudha *kedha*, Mysol *katim*, Santo *mokeo*, Mallicollo *bokol*, New Guinea *mele*, Pentecost *tual*, Aneiteum *ethi*, Kisa *ita*, Tanna *liti*, *riti*, *kadi*, Eromanga *sai*, Timuri *aida*, Savu *aisa*, Api *saka*, Mangarei *isaku*, Java *sigi*, Api *ta*, *tanga*, New Guinea *tika*, *dik*, Manitoto *nehi*, New Guinea *oser*, *siri*, *ossa*, Sumatra *sa*, *sado*, *sara*, *assa*, *satu*, *eso*, Ceram *san*, Gilolo *moi*, Tidore *remoi*.

Now, bearing in mind that in the above *r* is for *l*, we see that we have in these words for 1 simply the demonstratives *l*, *n*, *m*, *k*, *s* (*t*, *d*), *a* (*o*, *i*, *e*), of § 2, sometimes single, but usually two or more combined.

2. The numeral 2, Samoan *lua* (*luwa*), consists of the article *l*, and *ua* (*uwa*), 2. Thus in Tongan and Mallicollo the word is *ua* without the article, as it is also very often in Maori-Hawaiian when used with the personal pronouns to form the dual pronoun. The article *l* appears in Fatese and Malagasy in this word as *r*, and in Malay as *d*, so Bisayan *duha* (for *luha*).

The final *a* of *ua* is the ancient Shemitic dual ending or inflection; see the "Personal Pronoun," § 10, for the proof. And see the same for proof that an older form of *ua* is *uva*; seen in Mallicollo *ivan* (in *drivan*), Tagala *dalava, dalova, daluva* (Ceram *darua*), and Tidore *malofo* (Santo *morua*), 2. We have now to show that a still older form was *uma*.

In Samang *ua* is *be*, in Karon *we*, and in Tanna in the dual of nouns it is *mi*; thus "boat" (English) is *boat riti*, "one boat," *boat imi*, "two boats," in Fatese *boat erua*. The Tanna numeral 2 is *karu*. This shows how the article helps to disguise the original word: thus, suppose it was *uma*, with *r, ruma, ruva, ruwa, rua, karu*. So in Aneiteum we have *ero* and *ohwat* (for *ovă-t*) 2, New Britain *aiwut*, New Guinea (Papua Kowiay) *amoi, aboma*, Mairassi *amooi*, Duauru *bo, po*, 2: *aboma* is article *ab* (for *am*), see § 2, and *oma*, 2, so *amoi*, and *amooi* (*amui*) is article *am* and *oi* or *ui* (*ua, uma, oma*), 2, and *bo, po*, is article *am* and *o* (for *ua, uma, omu*), 2. Thus the only difference between Aneiteum *ro*, Tanna *ru*, and Duauru *bo, po*, is that different articles are used: *r* (for *l*), and *b* or *p* (for *m*), the word for 2 being the same *o, u* (for *oma, uma*), while between *aboma* and *bo* there is not any difference of article, both words alike being by phonetic corruption from the same original *amoma* 2 (*am* article, and *oma*, 2).

The original, therefore, was *oma* or *uma*. That this is of the same origin as the ancient Shemitic dual pronoun, Arabic *huma* (cf. Savu *lhua*, 2), Sabaean *hami*, "they-two," see "The Personal Pronoun," §§ 10, 15, 16.

3. The numeral 3. Malay *tiga* is the common Oceanic *tolu* or *tilu*, with the *l* elided, and the demonstrative *g* postfixed, as Aneiteum *eseik*. Thus compare Malay *ti-ga*, Aneiteum *esei-k*, with Ambrym *si*, Duauru *ti*, Mallicollo *roi*, Redscar Bay *toi*, Marquesas and Api *tou*, Pelew *othay*, in all of which there is the same elision of the *l*. Java *talu*, New Guinea *tola*, Rotuma *thol*, Ambrym *sul*, Api *selu*, Sumatra *tloo*, Mangarei *titu̥*. In some cases both *t* (*s*) and *l* are elided, as in Eddystone *kuay*, Jower (New Guinea) *re-oe*, in which *k* and *re* are the articles.

4. The numeral 4. In Malagasy *efatra* (Madagascar *effat*) the final *t* being the same as in Malay *ampat*, Fate *bāte*, and wanting in Samoan and Maori-Hawaiian generally. In Sumatra we have *ampah, opat, mpat, paat*; Tagala *apat*, Malay dialect *enpa*, Sula *riha* Savu *uppah*, Cayagan *appa*,

Saparua *haan*, Celebes *patanu*, Mafoor *fum*, Api *veri*; Ambrym *fir*, New Guinea *pali*, Segaar *fala*, Onim *faat*, Ceram *aāta*, New Britain *tigai*, New Guinea (Forrest) *tiak*.

5. The numeral 5 has the same article *l* as the numeral 2, Malagasy *dimy* being for *limy*, as Malay *duwa* for *lua*. Thus the word *lima* is *l*, the article, and *ima*, 5. Compare Sumatra *liema*, Rotuma *lium*, Pelew *aim* and *ain*, Tongan *neema*, and Redscar Bay *ima*, Carolines *lib*, Lifu *tipi* (for *lipi*), Easter Island *reema* and *reena*, Eromanga *rim* and *ring*, Fenua Galaia *djini*.

There is reason to think that *ima* originally began with a guttural *k* sound. Thus the word in Aneiteum is *nikma*, Tongan *neema*. Thus *lima* may be for *likma*. This is further supported by the following.

Often in Oceanic this same word is used for "hand" as well as for 5, as Aneiteum *ikma* (for *kima*), Redscar Bay *ima*, Santo *lima*. Sometimes the same word is used for both, but different forms of it in the same dialect—thus Eromangan for "hand" has *kop* (An. *ikma*), and for 5 *rim* (for *rikma*, An. *nikma*), so Tagala *camay*, "hand," *lima* 5, Bisayan *camot* and *lima*, Kayan *kama* and *lima*, Api *ma* and *lima*, and Lifu *ime* and *tipi*.

§ 5. In affirming that the Oceanic numerals are Shemitic, it is not meant that they are derived from the numerals of the Arabic or other existing Continental dialect, but from the same original source or mother-tongue.

The Shemitic numerals with which we may legitimately compare the Oceanic are in two groups:—

1. The literary Shemitic numerals, Hebrew, Assyrian, Syriac, Arabic, Sabaean (Southern Arabic, Himyscritic), Ethiopic, Modern Syriac, Modern Arabic, Tigre and Amharic, and the Arkiko, Harar, and Sokotra numerals.

All these as to the numerals constitute but one language, so that with certain exceptions as to the words for 1 and 2, the word for the numeral in one of them represents that for the same numeral in all the others. With respect to 1 and 2, each is represented by more than one word: thus, Heb. *'aste*, Assy. *estin*, = 1, as well as the common *akhad*, and Ethiopic, which is followed in this by the Tigre, Amharic, Arkiko, and Harar, has *kelëe* for 2, all the other members of the literary group having the word which in Hebrew is *shenaim*, or *shene*.

2. The Red Sea group of Shemitic numerals, found along the western shore of the Red Sea from Cape Guardafui to

Suez in the Somauli, Galla, Danakil and Adaiel, Shiho, and Bishari.

With the question of how far these dialects, any or all of them, are Shemitic we have nothing here to do. If any of them is radically non-Shemitic, the numerals of them which are Shemitic, and with which alone we are here concerned, must have been introduced or borrowed from Shemitic vulgar dialects of which they remain to this day a true fragment.

For the numerals of the Red Sea group, see the lists of Salt ("Voyage to Abyssinia") and Latham; for those of Sokotra, Wellsted ("Travels to the City of the Caliphs," &c.); for the modern Syriac, Stoddart's Grammar.

§ 6. The Numeral 1.

Oceanic (see § 4, 1).

ku, kai	*cha*, Mod. Syr
	k'ow, Somauli
kedha, kadi, keteh	kat, Sokotra
	chad, Mod. Syr.
	akhadu, Assy.
	engat, Bishari
aida, ita	*edu*, Assy.
	adde, Tigre
katim	*ahhdam*, Sabaean
satu, sada	'aste, Heb.
	istin, Assy.
tasi	cf. *edis*, ,,
nehi	*inek*, Shiho
tika	toko, Galla

For more, see below on the numeral 6.

§ 7. The Numeral 2.

Oceanic (see § 4, 2).

mi, be (am)oi, (am)ooi	cf. *huma*, Arabic
(ab)oma (b)o, ua, (dal)uva	cf. *hami*, Sabaean
ohwa(t) (dal-*uva, ohwa-t*)	
malofo	malobo, maloob } Bishari
morua	
(da)*luva, lua*	*lamma*, Shiho
lhua, duwa	*lebba*, Somauli
duha	lumma, Galla
	lummeh, Danakil

For more, see below on the numeral 7, and in § 17.

The Red Sea group agrees with the Oceanic, and differs from the literary Shemitic in using this dual pronoun, and with the article *l*, usually alone, but sometimes having the article *m* added to it (" The Compound Article," § 2), for the numeral 2. From §§ 13, 17 we see, however, that probably this was *the* original Shemitic numeral 2, and that the literary *shene* and *kelëe* are comparatively modern.

§ 8. The Numeral 3.

Oceanic (see § 4, 3).

tola, tolu, telo		*tela*, Mod. Syr.
talu		*thali* (third), Arabic
othay, ti		*adda,* Shiho
esei-k, ti-ga		
titu		*tata'ah,* Sokotra
thol		*tholth,* Syriac
selu	*s-ales,* Ethiopic,	*shelosh,* Heb.
re-oe, k-uay		*mi-h, mi-hay,* Bishari
etirom		*taltam,* Sabaean

For more, see below on the numeral 8.

§ 9. The Numeral 4.

Oceanic (see § 4, 4).

riha	*aru-t,* Amharic
enpa, ampah, appa	*arba',* Heb.
uppah, fa	*ubah,* Arkiko
effat, apat	*erbahte,* Tigre
paat, bāte	*arbat,* Sabaean
haan	*arban* „
fum	*arbam* „
veri, fir	*fere,* Danakil
tigai, tiak	*uddig, fadyg,* Bishari

For more, see below on the numeral 9.

§ 10. The Numeral 5.

Oceanic (see § 4, 5).

ikma (for *kima*)		*khemah,* Sokotra
	heimish,	*khumis* „
im, in		*konoyou, kum,* Danakil (in *kum-tum,* 50)
		kon, Shiho
		khansa, Assy.

lib, tipi (*ib, ipi*)	*ib*, Bishari
	amest, Amharic
	amoos, Arkiko
lima, liema, lium	*alhhams*, Arabic
djini	*shun*, Galla
	shan, Somauli
	(*sum*, and *essam*, Bishari, in the word for 8, see below)

For more, see below on the numerals 6, 7, 8, 9.

§ 11. The Oceanic Numerals 6—9.

	Malagasy.	Malay.	Papuan (Fatese).	Maori-Hawaiian (Samoan).
6.	enina (eni)	*anam*	latesa	ono
7.	fito	*tujuh*	larua	fitu
8.	valo	dalapan (salapan)	latolu	valu
9.	sivy	sambilan	lifiti	iva

1. All these Oceanic numerals are compound words, and the first part of the compound in every case is the numeral 5, or a fragment of it, with or without an article, the second or final part of the compound being the numerals 1, 2, 3, 4 (in 6, 7, 8, 9 respectively), of which 2 alone has sometimes the article *l* prefixed to it: thus 6 is *five-one*, 7 *five-two*, 8 *five-three*, and 9 *five-four*.

2. This is plain enough in the Papuan, but not so apparent in the other three branches. Hence even so able an investigator as Gabelentz deemed it peculiar to the Papuan numeral system, to which he gave the name of Quinary. It is in these Papuan numerals, with their transparent structure, that we get the clue to the exactly similar composition of the others, and that, as we shall see, with certainty. Fatese *latesa, larua, latolu, lifiti* are for *lima-tesa, lima-rua, lima-tolu, lima-bate*, as is proved by a comparison of dialects; thus, for instance, in the neighbouring island of Ambrym we have 1 *hu*, 2 *ru* (*lo*), 3 *sul* (*sī*), 4 *vit* (*fir*), 5 *lim*, which compounded give 6 *limse* (*livse, līse, luse, melipsies*), 7 *liuru* (*luru, melipo*), 8 *livsul* (*lisul, lusul, melipsī*), 9 *laifiet* (*rafet, lafar, liafer, meper*). Those enclosed in brackets are dialectical forms, and *melip* is for *melim*, Santo *molima* (§ 2, 7). *Melipo*, 7, is for *melim-ua*, the *ua*, 2, having no

article in this case, while it has the article *l* (*r*) in all the others. For another example see the Enganho numerals in Latham. In Yengen we have (article *n*) 5 *nim*, 6 *nimwet*, 7 *nimweluk*, 8 *nimweyen*, 9 *nimpobits*. In Fenua Galaia 5 *djini*, 6 *tchouo*, 7 *tembi*, 8 *ta*, 9 *toudjo*, in which note the *ou* is French, and the article is *s* changed to *dj*, *tch*, and *t*.

In these Fatese and Ambrym numerals the word 5, *ima*, to which the article *l* is prefixed is changed or corrupted into *a*, *u*, *i*, *v*, and *p* (*lu*, *li*, *liv*, *lip*, *la*). This brings us to observe that the first part of the numerals 6-9 is sometimes this word for 5 without the article. Thus to take Api, the island that lies between Fate and Ambrym, we find 1 *tai* (*ta*), 2 *tshua*, 3 *tolu*, 4 *beri*, 5 *tshima*, which compounded give 6 *ari* (*ora*), 7 *alua* (*olua*), 8 *arolu* (*orolu*), 9 *koveri* (*overi*), 10 *ruelma*, 20 *twelvalua*. In these *ima*, 5, is corrupted to *a* and *o*: *k* in *koveri* is an article (§ 2). Note, *tshua* and *tshima* (in neighbouring dialect *sima*) are for *lua* (*tua*) and *lima* (*tima*), as is proved by the words 7, *a-lua*, 10, *ruelma* (*rue lima*), and 20, *twelvalua* (*tue lima lua*). This change of *l* (through *t* or *d*) to *tsh* is found also, as will be seen, in Malay 7, *tuju* (*ju* for *duwa*, 2). In a Mallicollan dialect in Gabelentz and Latham we have 1 *sikai*, 2, *e-ua*, 3 *e-roi*, 4 *e-vatz*, 5 *e-rima*, which compounded give 6 *su-kai*, 7 *whi-u*, 8 *o-roi*, 9 *whi-vatz*; in another dialect these are 7 *wiu*, 8 *woroi*, 9 *obats*. In Bauro these are 7 *biu*, 8 *waru*, 9 *siwa*; in Marata 7 *fiu*, 8 *wharu*, 9 *tiwha*; in Fiji 7 *vitu*, 8 *walu*, 9 *thiwa*; and in Maori 7 *whitu*, 8 *waru*, 9 *iwa*; with all which the Malagasy and Samoan are identical. As to *sivy* (for *sim-vy*) it is *iva* (for *im-va*) with the article *s*, just as Fate *lifiti* is Mallicollo *whivatz* with article *l*, and Api *koveri* for *kim-veri* (Ambrym *lafar*, for *lim-far*), the same with article *k*. Celebes *kasa* and Sumatra *sakoorang* have both these articles *s* and *k*, and the latter is for *sekim-verang*, the final *ng* being the emphatic (for *n*) as in Malay *sambilan*, Java *sanga*. Forrest's Papuan (N. G.) has *siore* (for *sim-veri*). With Malagasy *sivy* are identical Amboyna *siwa*, *sia*, Savu, *sioh*, Ternati *siyu*, Celebes *sio*, Sula (*ga*) *tasia*, Fenua Galaia *toudjo*, Bouru *eshia*, *chia*, Santo *tshiwa*, Tagala *siyam*, Bisaya *siam*, Java *sanga*, Mysol *si*, *sin*, New Ireland *suok*.

4. Let it be noted that Bauro *biu*, Marata *fiu*, Mallicollo *whiu*, 7, have *u*, for *ua*, 2, without the article; and that Maori *whitu*, Malagasy and Samoan *fitu*, New Guinea (Marsden) *fita*, 7, have *tu*, or *ta*, for *tua* (for *lua*), or *ua*, 2,

with the article: that is, the sole difference between them is, that in the final part of this compound word the former have *ua*, 2, *without*, the latter have it *with* the article.

So Vanikoro *tembi* (for *sembi*), Taneanu and Fenua Galaia *timbi* (for *simbi*), Malay dialect *toufou*, Arru *dubem*, Tanema *roumbi* (for *lumbi*), Tembora *kumba*, 7, all have the same word, *ua*, for 2, as *bi*, *be*, *ba*, in the final part of this compound word, *without* the prefixed article.

5. The word 6, Samoan *ono*, is *o*, 5, as in Api *ora*, and *no*, 1, as in Api *ra*. Forster gives Friendly Islands *vano*, 6, where *va* (for *ma*, 5), as in *valu*, *varu*, 8. And both Samoan *no* and Api *ra* are phonetic variations of *sa*, 1, as also is the *ta* in Paama *hitai*, 6, Gilolo *butanga*, Tembora *bata-in*, and the *to* in New Guinea (Amberbaki) *ebetoe*, and the (final) *ra* in Ternati *rara*, Tidore *rora*, and the second *lo* in Pelew *lolom*, *malong*, and *l* in Caroline *hol*, and *no* in Bugis *onong*, 6. In the Laman dialect of Api we have *saka*, 1, and *oraka*, 6. In Malagasy *eni-na*, and Malay *ana-m*, the finals *na* and *m* are emphatics (see § 2, 2, 3), and *eni* and *ana* are identical with Samoan *ono*, Tongan (above) *vano*. That the *ni* of *eni*, *na* of *ana*, *no* of *ono*, is for *sa*, 1, by the change of *s* to *n*, compare New Ireland *lon* with Ambrym *lise*, *luse*, 6.

6. It only remains to explain Malay *tuju*, *delapan* or *salapan*, and *sambilan*, 7, 8, 9. We have seen, above, *l* and *s*, for instance, in *sivy*, *lifiti*, used as articles with the Oceanic numerals.

In Malay *tuju*, 7, the initial *t* is either this *s* or *l*, probably the *s*: in that case *tuju* is for *sudu* (Madagascar *sidda*, *titou*), for *sum-duwa* (Tarnati *tomdi*, Tidore *tumodi*), as Ambrym *luru* is for *lim-rua*. See above (3), Api *tshua* for (*tua*)*lua*.

Malay delapan, 8, is for *delima-n*. Compare Salibabo *delima*, 5 (see § 2, 5). The *n* stands for the *l* of *tolu*, 3, by the change of *l* to *n*. That this is so compare Savu *panu*, 8 (*tanu*, 3), where *panu* is manifestly the common Oceanic *varu*, 8. In Atshin (Sumatra) we have *lappan*, for *laman*, 8.

Varu, 8, is for *ma-lu*, Easter Island and Friendly Islands *varoo*, Papua (N. G.) *war*, Lombok *balu*, Caroline *wal*, *wan*, Tarawan *oanu*; Gilolo *itupangi* (for *itumani*); in Kayan *saya*, Fenua Galaia *ta*, all that remains of the words for "five-three" is in the one case *aya*, in the other *a* attached to the article *s* (*t*), and even this is equalled by Harar *sut*, for which see below, § 13, 3.

Malay *sambilan*, 9, is, by change of *t* to *l*, for *sambitan*; cf. Segaar *saputi*, Onim *saputi*, 9. The final *n* of sambilan is an emphatic (see § 2, 2). Onim *saputi* is for *sam-puti*, as Fate *lifiti*, is for *lim-fiti*, and Malay *sam-bilan* for *sam-bitan*, all equally being "five-four," or 9.

§ 12. Turn now to the Red Sea group. The Bishari has 1 *engat* (*engaro*), 2 *maloob* (*malobo*), 3 *mih* (*mehay*), 4 *uddig* (*fadyg*), 5 *ib* (*eyyib*), which compounded give 6 *suggoor* (*assagour*), 7 *seramab* (*essarama*), 8 *sumhai* (*essambay*, *essamb-ay*), 9 *shedig* (*ogamhay*). For the first five of these see above, §§ 6-10. The *b* (for *m*) in *seramab*, 7, is emphatic (§ 2), and *rama* is identical with *loob*, 2, originally *looma*, i.e., *luma*. The *goor* of *suggoor*, 6, is identical with the *gat* of *engat*, 1; the *hai* of *sumhai*, 8, with the *h*, or *hay*, of *mehay*, 3; and the *dig* of *shedig*, 9, with *uddig* (*fadyg*) 4 (for the final *g*, see § 2, 4, and § 9). Here then we have exactly the same system as the Oceanic, § 11, and the article *s* is the same as the Oceanic article *s*, § 11; even as in *ogamhay*, 9, we have the same article *k* as in Api *koveri* (for *kam-veri*) 9. In Galla 6 is *ja*, or *dzha*. In Danakil and Shiho 6 is *leheye*, lelehe, *leh*; 7, *melhene* for *ma-lhama* (Java *petu* for *me-luma*); 8, *bahara*, *vahr* (Friendly Islands *varoo*, New Guinea (Forrest) *war*); 8, Bishari is *sumhai* (*kai*, 3), and Somauli sedeid, for sem-deid (*sudde*, 3). For 9 we have in Danakil *segala*, compare Sumatra *sekuru-ng*. Thus in the Red Sea group we have in the first part of the compound words for 6-9 the articles *l*, *s* (*t*), and *g* (*k*), and only in the Danakil and Shiho 7 and 8 no article. But in this group in the compound word for 7 the final part, or word for 2, is never without the article: thus Somauli *t'dubba* (*te-luma*), Galla *toorbah* (*tu-luma*), and Shiho *melhen* (me-*lhama*), 7.

The literary Shemitic words for the numerals 6-9 are compounded like those of this Red Sea group and the Oceanic. In Ethiopic we have them as—6 *sedes* (Heb. *shesh* is a phonetic corruption for *shedesh*, Arabic *sit* for *sides*), 7 *seb'e*, 8 *seman*, 9 *ts'e*, and in Sokotra 6 *yitah*, 7 *yibi'ah*, 8 *tamani*, 9 *sa'ah*.

Carefully noting whether the article is the same or different, compare—

6	Fate	*la-tes*,	with *se-des*
6	Ambrym	*lise*,	with *shesh*
7	Vanikoro	*tembi*	with *seb'e*

7	Arru	*dubem,*	with *sabam,* Sabaean
8	Gilolo	*itupangi,*	with *tamāni*
9	Celebes	*sio,*	with *sa'ah*

Thus in the compound words for 6-9 the literary Shemitic uses only the articles *s* and *t*, while the Oceanic and Red Sea group use other articles, as *l* and *k*, as well as *s* and *t*. The difference between *la-tes* and *sedes* is simply that of the two mutually equivalent articles *s* and *l*; while *tembi* (*sembi*), and *sebe* (*sembe*), *itupangi* (*itumani*) and *tamani*, and *sio* and *sa'ah* are absolutely identical (if we except slight phonetic changes), and have even the same article. In the word for 7 the literary Shemitic differs from the Red Sea group, and agrees with some of the Oceanic dialects (see § 11, 4), in never using the article with the word for 2 in the final or second part of the compound. This final part is *be* in Ethiopic *sebe*, and *bi* in Vanikoro *tembi*, identical with Samang *be*, Karon *we*, Tongan *ua*, Tanna *-u* and *mi*, Aneiteum *-o*, and *ohwa-t*, Tagala *-uva*, Papua Kowiay *-oma*, and Mallicollo *ua*, and *va(-n)*, 2.

§ 13, 1. The Numeral 6. See § 4, 1, § 6.

With a prefixed article the same or different.

§ 11—

lates (*lim-tes*)	*sedes*, Eth.
lise, rora, rara	(*sem-des*)
tchouo	*shesh*, Heb.
	dzha, Galla
su-kai (*sum-kai*)	*suggoor*, Bishari
	(*sum-gat*)
lolom (*lim-lo-m*)	*lelehe*, Danakil
	(*lem-lehe*)
	leh, Shiho

Without a prefixed article.

§ 11.—

hitai, oroi, ora, ari (*ima-tai*)	*yitah*, Sokotra (*yima-tah*)
ebetoe, bata-in, butanga	
malong, hol, vano	Same as Arabic, only wanting
onong, ono, eni	initial *s*
enina, anam	

2. The Numeral 7. See § 4, 2, § 7.

a. The first part of the compound with, the second without, a prefixed article.

§ 11.—

tembi (*simbi*, *sim-uma*)	*siba*, Assy. (*simba*, *sim-uma*)
timbi	*sebe*, Eth.
dubem	*sabam*, Sabaean
sik (§ 2, 4)	*sate* (§ 2, 5), Harar
	sho'a, Mod. Syr.
	sua, Ehkili
roumbi (for *lumbi*)	
kumba	

b. The second part of the compound with, the first without, a prefixed article.

§ 11.—

fito, *fitu*, *fita*, *petu* (Java) (for *me-luma*)	*melhene*, Danakil
	melhen, Shiho (for *melhem*, for *me-lhuma*), cf. Savu *lhua*, 2

c. Both parts of the compound without a prefixed article.

§ 11.—

biu (*ima-uma*)	*yibi'ah*, Sokotra (*ima-uma'ah*)
fiek, *fiet* (§ 2, 4, 5) (*ima-umak*, and *ima-umat*)	This is same as Arabic, only wanting initial *s*

d. Both parts of the compound with a prefixed article.

§ 11.—

sidda, *titou*	*t'dubba*, Somauli
tuju, *tomdi*, *tumodi* (for *sim-luma*, or *sum-luma*)	*toorbah*, Galla
	seramab, *essarama* } Bishari (for *sim-luma*, or *sum-luma*)

3. The Numeral 8. See § 4, 3, § 8.

§ 11.—

a. With prefixed article.

itupangi (*itum-ani*)	*themania*, Arabic (*them-ania*) *tamāni*, Sokotra
saya, *ta*	*sut*, Harar
lappan (*lim-an*)	*sumhai*, Bishari
delapante (*delam-ante*)	*shumunte*, Tigre (With B. *hai*, 3, cf. Mairassi *aai*, 3, in *iwor-aai*, 8).

b. Without prefixed article.

varoo, *war*, *baloo*, *wal*, *wan*, *oanu*, *panu* (for *ima-lu*, *orima-alu*, the *lu* becoming *ru*, *nu*, *l*, *r*, and *n*; *lu* is for *tolu*, *selu*, 3)	*bahara*, Danakil *vahr*, Shiho (for *ima-hara*, *ima-ahr*, *ahr* for "*adda*," 3; and compare Tanna ka *har*, 3, for, as it is in another Tanna dialect, ki, *sil*, 3)

4. The Numeral 9. See § 4, 4, § 9.

§ 11.—

chia, *tshiwa*	*tsha*, Syriac
tasia, *toudjo* (*tudjo*)	*tesha*, Heb.
eshia	*itshi*, *itsha*, Mod. Syr.
si, *sio*, *sia*, *sioh*, *siyu*, *kasa*	*sa'ah*, Sokotra
sin	*zeythan*, Harar
sanga	*zatang*, Amharic
siyam, *siam*	*tesam*, Sabaean
suok (*sim-vak*)	*shedig*, Bishari (*shim-fadig*)
sapuli, *siore*, *sakoorang* (*sekim-verang*)	*segala*, Danakil (*segim-vela*)
sambilan, *saputi*	
koveri (*kim-veri*)	*ogamhay*, Bishari (cf. Saparua *haä*, 4)
lifiti (*lim-fiti*)	
lafar (*lim-fir*)	
iva (*ima-va*)	
whivatz (*ima-vatz*)	

§ 14. The Numeral 10.

1. In the Shemitic and Oceanic the word for 10 is a word originally meaning the whole, the completion, combination or sum, and then the same in reference to the digits, that is, 10. For exceptions to this, see 6 below.

2. The one word used for 10 in the literary Shemitic is (*'asar*, "combination") in Hebrew *'asar*, Syriac *'sar*, 10. This in modern Arabic is found as *asher* and *ash*, and in Harar as *assir* and *asse*. In Matabello *sow* is 10, but in *terwahei* 11, *ternorua* 12, *teranrua* 20, *terantolu* 30, the word for 10 is *ter*, which is perhaps for *ser*, cf. Syriac *'sar*, 10; compare Tembora *sarone*, Mangarei *turu*, 10; and also, perhaps, Uea *ach*, 10, in the numerals 11–15.

3. The common word for 10 in the Red Sea group is in Shiho *tummun*, *tamum*, *tan*, *tun*, in Danakil *thubban*, *tum*, and *tunna*, *tubban*, *tun*, Bishari *tummun*. This is the word which is in Arabic *tamam*, "integer, completus numero," and *tam*, and *tum*, "perfectio, finis, complementum," the verb being *tamma*, "totus, integer, perfectus" (Freytag); in fact, it is probably the Arabic word.

Fiji *tini*, Ceram *tinein* (*tine-in*), 10 (note the change of *m* to *n*, as in the Red Sea group), are of the same origin as the Arabic.

4. The common Oceanic word for 10 is in Malay *sapuluh*, Samoan *sefulu*, Malagasy *folo*, Philippines *apalo*, Sanguir *kapuroh*, Salibabo *mapuroh*, Sula *poha*, Savu *bo*, Mysol *lafu*, Matabello *sow* (for *safu*), Ceram *opooloo*, *hutu*, *fotusa* (= Malay *balas*), *vuta*, *ocha*, *husa* (with this compare Uea *ach* in 2 above), Rotti *hulu*, Timuri *nulu*, Madagascar *nel*, Pome *awrah*, Moor *toverah*, Seroci *soerat*, Ansoes *hoera*, Dasin *arisa*, Papuan *samfoor*, Mindanao *sanpoolu*, Santo *sinafulu*, *sabulu*, *sanafuru*, Marata *tangafuru*, Aoba *hangafulu*, Mallicollo *hangafulu*, *sangafur*, *sangaful*, *singeab*, *singab*, Ambrym *sanghul*, *sangul*, *songapi*, Santo *ulatea* (tea=1), Pentecost *siamnoh*. In this word is clearly seen the disguising effects mentioned in § 3; and it will be observed that all the articles in § 2 are used with this word in the examples just given.

The Malay *puluh*, 10, compared with *bulah*, "the whole" (Crawford, "Malay Dict."), and Tongan *fulu*, 10, compared with *fuli*, "all, in number not mass, or quantity of bulk" (Mariner, "Tongan Dict."), show that this word used for 10 originally meant "all," or "the whole," that is, the sum, then

10, the whole or sum of the digits. Of course, it might, if so used, mean *any* sum; and for examples of its denoting other sums, namely, 100 and 10,000, see § 15. This word *puluh, palo*, is in Arabic *bulugh* or *bulu'*, "perfectio," *balugh* or *balu'*, "summa (idiom. vulg.)," *mabelagh*, or *mabla*, "summa quae oritur ex addendio numeris vel multiplicandis," the verb being *bala'*, "pervenit, contigit terminum propositum . . . . consummatus fuit, pervenit ad finem" (Freytag); that is, the Arabic word means the consummation or completion or the whole or the sum obtained by adding or multiplying, and might therefore denote any sum, see § 15.

5. In like manner the word *uma*, "all," in Samoan, is in Hawaiian, as *umi*, 10. The word *manu* in Fatese a multitude, or 1000, Samoan a "myriad," or 10,000, in Guham, as *manud*, is 10. The word *ulu* in Tongan and Malay "head," is in Tongan also 10. In Duauru 10 is *dekau*, of which Gabelentz says that it "ist das polynes *tekau* (zehn Paar"). The fact is, however, that *te* (*de*) is the article, and *kau* means "multitude" or "a mass." Hence in Fatese with article *m*, in one dialect, as *umkau*, it means "all," "the whole," in another, as *makau*, "a bunch or cluster" (of fruit, as nuts). In Tongan it is a sign of the plural number. In Samoan as *'au*, it is "a bunch, a troop, a gang, a shoal." In Tongan *tekau* is "a score," or 20, while in Maori, as in Duauru, it is 10.

6. In some Oceanic dialects 10 is expressed by "two-fives," or "two-of-five," as Fate *ruelima* (*rua*, 2, *lima*, 5), Lifu *luepi* (*lua*, 2, *ipi*, 5) Paama *ha lua lim*. Aneiteum *nikman ero* is "his two hands." Tanna *karilum karilum* is literally (*kari* for *kadi*) "one-five one-five," or "five five."

Notwithstanding, the Fatese numeral system is as thoroughly *decimal* as the Malay or even the English.

§ 15. The Numerals 100, 1000, &c.

The word in Malay *sapuluh*, in Moor *toverah*, 10, is in Fate *tifili*, 100, in one dialect, 10,000 in another. With this compare Danakil and Shiho *bōl*, 100. Malay *ribu*, Java *ewu*, Santo *riwun*, Malagasy *arivo* (compare Malagasy *arivoarivo*, "innumerable"), 1000, is evidently like the Fatese and Tongan *manu*, or *mano*, 1000, Samoan 10,000, originally a multitude, large number, or "myriad." Compare Hebrew *ribo*, Syriac *rebu*, "a myriad." Samoan and Tongan *afe*, 1000, is to be compared with Hebrew *alef*, Arabic *'alf*, Ehkili *of*, 1000. This word in Ethiopic is 10,000. It originally denoted a multitude or large number.

§ 16. The Malay and Fatese ordinals are formed by prefixing to the cardinals the article *ka*, as *ka lima*, Malay and Fatese, "fifth"; Amharic and Eromangan effect the same by suffixing the demonstrative *ng*, as Amh. *andanga*, Ero. *saiungi*, "first," Amh. *sostanga*, Ero. *deselungi*, "third." The expressions "once," "twice," "thrice," or "a third time," &c., are formed in many Oceanic dialects by prefixing to the numerals *ba*, or *va*, or *baka* or *vaka*, as Api *fatai*, *valua*, *varelu*, *vaveri*, &c., Paama *varais*, *valua*, *vatolu*, *vahati*, *valima*, &c., Mallicollo *faksoka*, *fakaru*, *fakatir*, *fakabit*, *fakarim*, &c., Fiji *vakadua*, *vakarua*, *vakatolu*, &c., Fate *bakatolu*, or *fakatolu*, &c., Samoan *faatolu*, &c. In Malagasy as *faha* (for *faka*) we have it in *faharoa*, *fahatelo*, &c., for the ordinal 2nd, 3rd, &c. Now leaving out the *ka* (to be explained in another paper), we have *ba*, or *va* (sometimes used without the *ka*), which is found similarly used in Ethiopic as በ, *ba*, thus in the Gospel by Luke, xxiii. 22, for Greek τριτον, there is in the Ethiopic Version *basales*, in the Fiji Version *vakatolu* (cf. Api *vatolu*). In the Tigre Version it is *abesalesai*, the initial *abe* being for the Ethiopic *ba*. The identity of the Ethiopic (*sales*) and Oceanic word (*selu*, *tolu*) for 3 has been shown above, § 8; and it is certain that this prefixed *ba*, Tigre *abe*, Fiji, &c., *va*, *ba*, are the same particle of the same origin, though the full proof must be reserved till the Prepositions come to be discussed. In the meantime it may be pointed out that this implies, what will be fully shown in the proper place, that one of the most essential particles of the Shemitic languages, the much and variously used preposition በ, ܒ, ب, &c., (*b*, *v*); and one of the most essential of the Oceanic particles *ba* or the *ba* in *baka*, used not only with the numerals as above, but in other ways, and particularly in forming the so-called causative (Fiji *vaka*, Fate *baka* and *faka*, Mahaga *va*, Duauru *ve*, Lifu *a*, Samoan *faa*, Aneiteum *imi*, Eromangan *ampi*, Malagasy *ampi* or *mpi*, &c., &c.), are identical as of the same origin.

§ 17. As to the origin of the Shemitic numerals, it may be added to what has been already said that *shenaim* and *kelëe* mean 2, only because of the dual ending attached (*a*) to them, and that as this dual ending was used in the Shemitic languages attached to *huma*, "they-two," at least *before* it was used attached to these two words, they must be held as comparatively modern. The Shemitic *hham-s*, 5, is connected with *qometz* (Hebrew) "fist," as Bisayan (*l*) *ima*, 5, with *camot*, "hand," see § 4, 5.

§ 18. The foregoing does not profess to be a complete exhibition of the subject of which it treats, though sufficiently so to show that the Oceanic numeral system and numerals are Shemitic.

APPENDIX ON THE AUSTRALIAN AND TASMANIAN NUMERALS.

In some Australian dialects there are separate words only for 1 and 2, exactly as in Torres Straits and on the adjacent coast of New Guinea; in some for 1, 2, and 3; and in some for 1, 2, 3, 4, and 5. But it may be laid down as a general rule that, as in Oceanic, these separate words are the same everywhere, in so far as they are found used. The following five comparative tables are designed to *prove* these separate Australian numeral-words identical with the Oceanic. The Oceanic words which are compared in the tables are the same as those explained in the foregoing pages, and reference to those pages will explain every question that can arise regarding them. The only question that can arise as to the Australian here compared, which fairly and fully represent the numerals of the whole Australian group, is as to the prefixes and postfixes attached to them, and all that seems necessary to say in this place is that they are manifestly identical with the corresponding Oceanic prefixes and postfixes pointed out in § 2, and for the most part also seen actually attached to the Oceanic words in the following tables:—

The Numeral 1.

Oceanic.	Australian.
Mallicollo, *bokol*	Lake Macquarie, *wakol*
Middleburgh, N.G., *mele*	Kamilaroi, *mal*
Seroci, N.G., *boiri*	Omeo Tribe, V., *boor*
Eddystone, *kamee*	Port Lincoln, *comia*
New Britain, *kapeau*	Wimmera, V., *keyap*

Oceanic.	Australian.
Maramasiki, *mora*	S. Tasmania, *marrawah*
N. Caledonia, *walait*	Van Dieman Gulf, N.A., *warat*
Manatoto, *nehi*	Murray River, Echuca, *enea*
Tanna, *riti*	Port Essington, N.A., *erad*
Maclaycusti, N.G., *kukun*	Swan River, W.A., *gyn*
Tanema, *kero*	Moreton Island, *karawo*
Malagasy, *iraika*	Terrutong, *roka*
Sula, *hia*	Lower Goulburn, *eya*
Pelew, *tong*	Wollondilly River, *medung*

The Numeral 2.

Guebe, *pilou*	Swan Hill, V. *polay*
N. Caledonia, *waroo, paroo*	Adelaide, *purlai-tye*
N. Caledonia, *puaru*	Border Town, *pulla-k*
Seroci, N.G., *boroe*	S. Tasmania, *pooalih*
Lifu, *luete*	Wannon, V., *bolate*
	Moreton Bay, *bulla*
	Wellington, N.S.W., *bula*
	Lake Macquarie, *buloa-ra*
Madagascar, *rica*	Raffles Bay, *orica*
Ansus, *kodu*	King George's Sound, *kadie-n*
Aneiteum, *ohwat*	Tarpeena Tribe, *bowait*

The Numeral 3.

Java, *talu*	S. Tasmania, *talleh*
Savu, *tanu*	King George's Sound, *taan*
N. Caledonia, *wateen*	Moreton Island, *madan*
N. Caledonia, *kartien*	
N. Caledonia, *puartien*	Moreton Bay, *mudyan*
Guebe, *pitoul*	Peel River, *purla*
Sula, *gatil*	W. Australia, *ngarril*
Enganho, *agoloe*	Wollondilly River, *colluerr*
Astrolabe, N.G., *alub*	Kamilaroi, *guliba*
Waigyu, *kioro*	Lake Macquarie, *ngoro*
Tanna, *kahar*; Arfak, *kar*	

The Numeral 4.

Ambrym, *veri, fir, vier*	
Api, *vari, bere*	Wollondilly River, *borre*
Papua Kowiay, *aiwera*	E. Australia (Threlkeld), *wara*
Ebon, *emer*	River Peake Tribe, *merrie*
Segaar, *fala*	S. Tasmania, *wullyawa*
Enganho, *aopa*	Port Lincoln, *wema*
Sumatra, *ampe*	

The Numeral 5.

Amberbaki, N.G., *mer*	S. Tasmania, *marah*
Omar, *matisi*	Lachlan (Regent River), *matto*
Uea, *thabumb* (for *lima-m*)	Cape York Tribe, N.A., *tabama*

These words all radically mean "hand," and they are all the same, though disguised by prefixes, postfixes, and phonetic change, see § 3. Compare Api *ma* = Peel River *ma* = "hand." As to *marah* 5, the commonest Australian form of the word for "hand" is *m-r*. Major Mitchell observes that when the natives of Regent River gave him *matto* for 5, they held up the fingers. At the same place *matto matto* is 10, with which compare Tanna *kirilum kirilum* 10, see § 14, 6.

In conclusion, it seems certain that the Australian and Tasmanian numeral-words are Oceanic. The wider question as to the relationship between the Australian group of dialects and the Oceanic could not with propriety be entered upon here, but may be best entered upon from the solid foundation thus laid as to the numerals.

ART. II.—*Descriptions of New, or Little Known, Polyzoa.*

PART X.

BY P. H. MACGILLIVRAY, M.A., M.R.C.S., F.L.S.

[Read 11th March, 1886.]

Family CATENICELLIDÆ.

Catenicella urnula, n. sp. Pl. I., fig. 2.

ZOŒCIA vase-shaped; mouth slightly hollowed below; anterior surface with seven large shallow fenestræ; lateral processes large, erect, sharply pointed, frequently a small avicularium on the front of one or both, a shallow hollow on the superior surface. Posterior surface with a narrow, vertical, thickened band, from which two processes extend on each side to the margin of the cell, leaving shallow depressions.

Port Phillip Heads, Mr. J. B. Wilson.

This species, of which I have only seen one small fragment, probably attains a considerable size. It is allied to

C. plagiostoma and *intermedia*, but is readily distinguished by its straight mouth, the shallowness of the fenestræ, the shape and structure of the avicularian process, and the markings on the back of the zoœcia.

Catenicella venusta, n. sp. Pl. I., fig. 1.

Zoarium small; branches slender, crystalline. Zoœcia elongated, very narrow, with usually a sharp, barren process on one side, and a thicker, aviculiferous one on the other; mouth subcircular, a narrow, sublateral vitta extending about two-thirds of the length of the cell; surface in front slightly papillose. Oœcia elongated upwards, adnate on the cell above, with a vertical thickened-line (showing the closure of a fissure), margin with a thickened rim, inside which is usually a series of white-bordered puncta.

Port Phillip Heads, Mr. J. B. Wilson.

This lovely species is totally distinct from any previously described. The zoœcia are remarkably slender. The avicularian processes are directed upwards and forwards; one is usually sharply pointed and without avicularium, while the other is thicker, and is surmounted by a minute avicularium. The oœcium is very peculiar. It is adnate to the zoœcium above. It has a thickened margin, within which there is usually a row of white-bordered puncta; down the centre is a narrow band, slightly clavate above, marking the site of an original fissure, the lower part of which is still occasionally not quite filled in.

Family ESCHARIDÆ.

Mucronella avicularis, n. sp. Pl. I., fig. 3.

Zoarium encrusting. Zoœcia irregular, decumbent, immersed, or oblique; mouth with a quadrate denticle or process on the lower lip; surface obscurely granular. Numerous large, broadly spatulate avicularia on large calcareous elevations irregularly scattered over the zoarium. Oœcia subglobular, elevated.

Port Phillip Heads, Mr. J. B. Wilson.

In this peculiar species the zoœcia are irregularly arranged, being sometimes nearly horizontal, and at others more vertical, very much as in *Cellepora*. The most characteristic mark is the great development of the avicularia. These are situated on much elevated, cell-like processes; they are shortly and broadly spatulate; the mandible is peculiar in its structure, the lower half (as seen *in situ* without decalcification or staining) being differentiated from the rest by a thick, chitinous hoop.

Family TUBULIPORIDÆ.

Stomatopora geminata, n. sp. Pl. II., fig. 3.

Zoarium branched; branches obscurely concentrically rugose; surface with numerous brown, white-bordered puncta. Zoœcia separated by shallow sulci, opening in pairs or triplets; mouths projecting, turned rectangularly forward, and closely united together laterally throughout their length.

Port Phillip Heads, Mr. J. B. Wilson.

At once distinguished from all the other species by the arrangement of the cells in pairs or triplets, with the free oral extremities united laterally, and turned rectangularly forward.

Diastopora cristata, n. sp. Pl. II., fig. 1.

Zoarium either encrusting and with portions raised into bilaminate lobes, or wholly bilaminate, the laminæ parted by a thin calcareous septum, the margin of which is produced beyond the zoœcia to form a crest-like ridge. Zoœcia opening on both sides of the lobes; crowded, free for a considerable extent; immersed portions separated by shallow grooves; surface closely and finely punctate, except the free part, which is smooth or obscurely ringed; mouth circular or oblique. Oœcium a large inflation of the zoarium.

Port Phillip Heads, Mr. J. B. Wilson.

In the figured specimen the zoarium consists of a single layer, closely surrounding a branched mass of the calcareous tubes of a small annelid, from the free-growing edge of which in parts extends the margin of a thin calcareous basal lamina. From various parts of the encrusting layer spring small bilaminate lobes, the laminæ of which are separated by a thin calcareous septum (identical with the basal plate of the encrusting part), the edge of which projects in a crest-like manner beyond the zoœcia. In another specimen the zoarium is almost entirely bilaminate, the lobes being considerably larger, and only a small part encrusting; however, here also the laminæ are in part separated to embrace an annelid tube.

Diastopora capitata, n. sp. Pl. II., fig 2.

Zoarium consisting of bilaminate lobes, rising from an encrusting layer by a narrow, stem-like portion, and expanding above; laminæ separated by a calcareous septum, slightly produced beyond the zoœcia. Zoœcia slightly free at the extremities, indistinct, minutely punctate.

Port Phillip Heads, Mr. J. B. Wilson.

The only specimen I have seen consists of a cluster of four lobes, rising from an encrusting layer of zoœcia. Each lobe is narrowed and thicker below, expanded, thinner, and undulated above, and usually divided into two secondary lobes. The summit of the lobes is flatter than in the last, and cellular from the opening of imperfectly formed cells. The zoœcia are not so numerous on the stem-like portion, but increase in number and prominence upwards, until towards the summit they are considerably elongated to assume a corymbose appearance. In the encrusting part a few of the zoœcia are closed, the lid having a minute perforation in its centre. In both species the dividing septum is not visible on the sides of the lobes, but only on the summits.

The genus *Mesenteripora* was proposed by Blainville, and has been adopted by D'Orbigny, Smitt, Busk, and others for those diastoporidan forms having the zoarium formed of two layers of zoœcia, parted by a thin calcareous septum, and opening on both sides. One species (*M. meandrina*, Serles-Wood) has been found recent in Greenland and on the coast of France, as well as fossil in the crag; and several others have been described from various fossiliferous formations. The two species here described are especially interesting, as being the only other recent forms referable to *Mesenteripora*, and also as showing that there is no valid distinction between that genus and *Diastopora*. *D. cristata*, when enveloping the bundle of annelidan tubes, is a *Berenicea;* when encrusting a nodule it is a true *Diastopora*, and when erect and bilaminate a *Mesenteripora*. *D. capitata* approaches more to a typical *Mesenteripora*; but still the gradation is so complete through the two species as to show that, the zoœcial characters being identical, and the zoarial merging into each other, there can be no real generic difference.

EXPLANATION OF FIGURES.

Plate I.

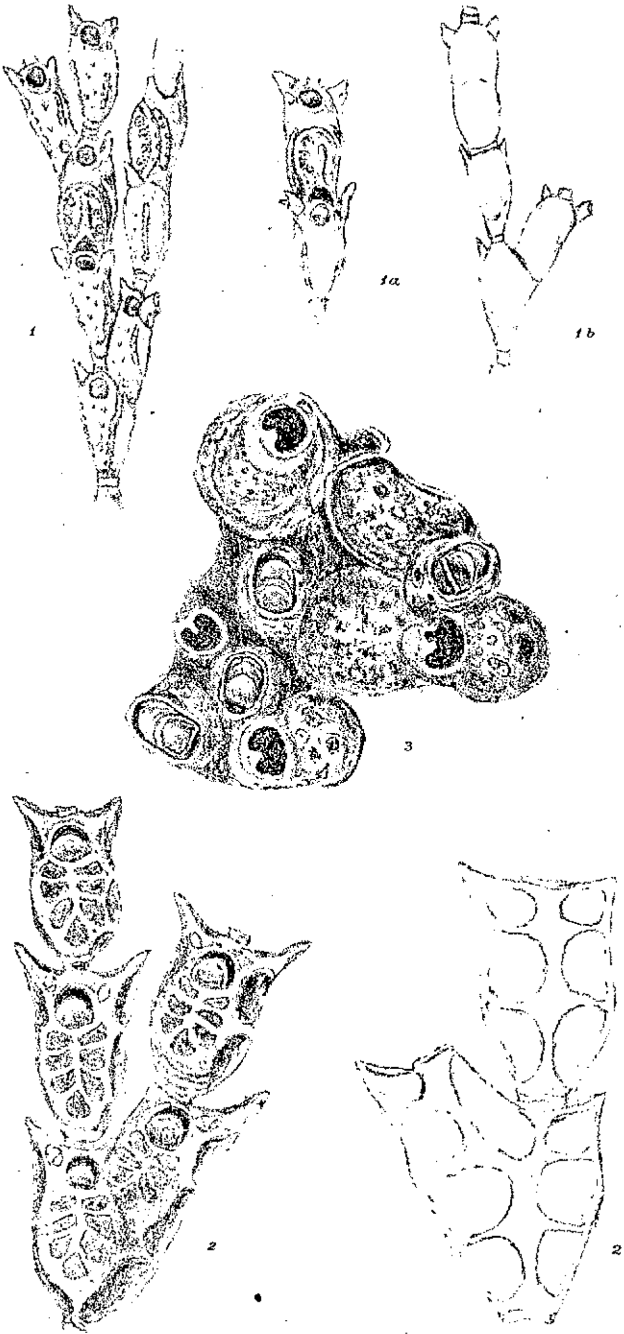
Fig. 1. *Catenicella venusta*. Fig. 1*b*. Back of same.
Fig. 2. *Catenicella urnula*. Fig. 2*a*. Back of same.
Fig. 3. *Mucronella avicularis*.

Plate II.

Fig. 1. *Diastopora cristata*, showing one surface of a lobe, with the extension of the calcareous septum. Fig. 1*a*. Another portion of the same specimen, showing an encrusting part, a bilaminate lobe, and an oœcium.
Fig. 2. *Diastopora capitata*, natural size. Fig. 2*a*. One of the isolated lobes magnified.
Fig. 3. *Stomatopora geminata*.

The wrong scale has been placed with Plate II., the figures of which are only magnified about half the extent of those in Plate I.

Plate I.

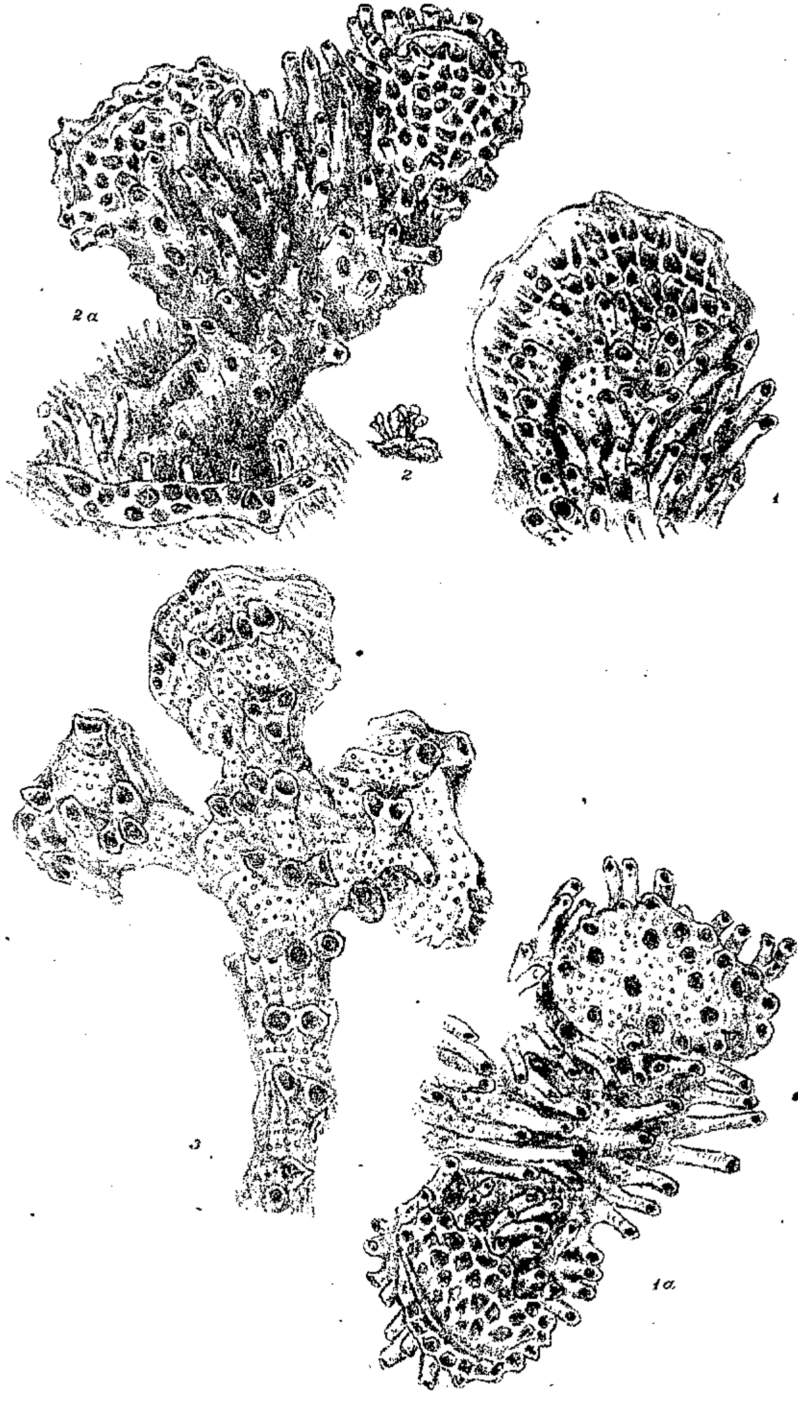


1/100 inch

P.H.McG. del. & lith.

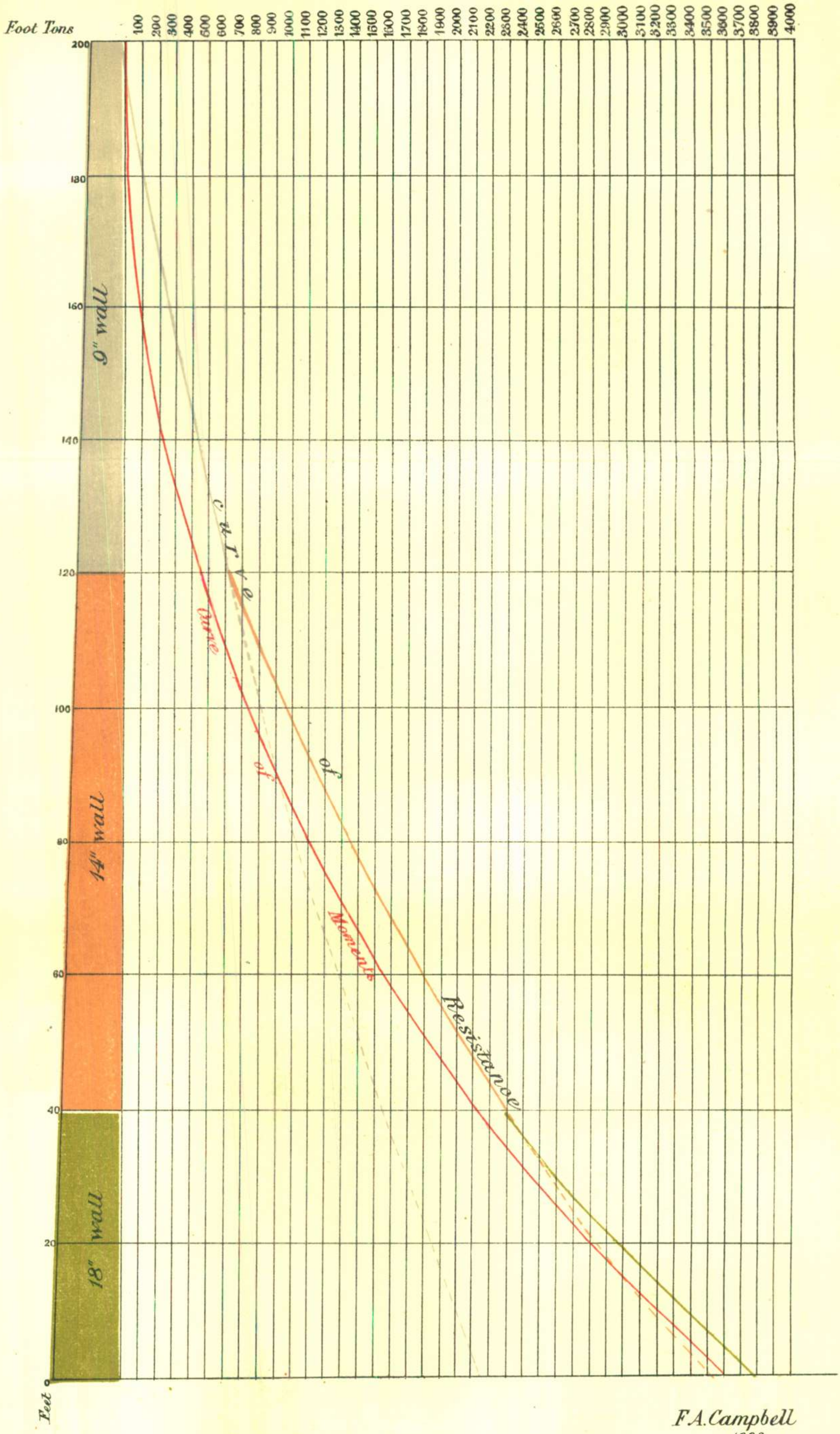
Froedel & Co. imp.

Plate II



$\frac{1}{100}$ inch

D.H.McC del & lith   C.Troedel & Co imp.



F.A. Campbell
1886

Scale 20 ft. to 1 in. Vert.l
" 800 ft. tons to 1 inch Hor.l

ART. III.—*The Stability of Structures in Regard to Wind Pressures.*

PAPER NO. 1.

BY FRED. A. CAMPBELL, C.E.

[Read 8th April, 1886.]

THERE is no force upon earth more variable and uncertain than that of the wind. It approaches from every quarter; it moves in circles as well as straight lines, and vertically as well as horizontally. Its force may be as steady and continuous as that of gravitation, or as intermittent and impulsive as the blows of a battering-ram; whilst in strength it varies from the gentle zephyr that will hardly lift a feather, to the mighty hurricane which levels every obstacle to the ground.

Fully recognising then the existence of this invisible, omnipresent, ever-varying force, to which every structure is more or less exposed, it becomes a question of serious import to the engineer and architect as to what is the best—that is, the safest and most economical way of providing for it. This question is continually pressed upon our notice by the failure of structures around us during heavy gales. It was especially brought home to us in a very startling manner by the destruction in 1879 of the great Tay railway bridge.

Having to erect any structure which shall be exposed to certain forces, the designer naturally ascertains in the first place as nearly as possible the extent of such forces. If these can be determined with tolerable accuracy, as in the case of a dam to retain water, or a column to uphold a known dead-weight, the way is clear, and the designer has simply to apply known laws, stresses which are calculable being provided for by the disposal of material whose resistance is calculable. But if, on the other hand, the force is one which is beyond the range of exact knowledge, the task is of a totally different kind.

To this latter class the pressure due to wind undoubtedly belongs, as will be evident from what follows.

It might be urged that if we have not precise data to start with, any attempt to solve the problem scientifically must be useless, and that the best method must be to work from precedent. For instance, from observation, we find that a structure of certain dimensions has successfully resisted all the gales experienced since its erection; therefore, in building structures in similar positions we cannot go astray in imitating such an example.

This course, though one which I believe to be frequently adopted, and with some reason, in small and inexpensive structures, is, where important structures are concerned, both unscientific and unsound. It is no guarantee of the safety of the structure, still less of its economy.

Notwithstanding the uncertainty as to extreme wind pressures, I believe that, by bringing observation, judgment, and experience to the aid of calculation, the subject can be dealt with in a manner both scientific and logical, disposing of the material to the best advantage, and securing all reasonable safety with the utmost degree of economy.

To investigate the matter as proposed, it will be necessary to consider a number of points in connection therewith, which for convenience I have classed under four heads, viz.:—

1. The maximum pressure of the wind at or near the locality of the proposed structure.
2. The nature of the situation as to shelter or otherwise.
3. The height of the structure above the ground, and the nature of its construction.
4. Its value, use, and whether its failure would involve loss of life or damage to adjacent property.

First. *The maximum pressure of the wind at or near the locality of the proposed structure.*

Stations for observing and recording the pressure of the wind are usually confined to the Government Observatories. This is the case, I believe, in the Australian colonies.

As these observatories are usually upon commanding positions, with the anemometer fixed high above the ground, we may safely assume that the records from these points are not likely to be exceeded in other localities.

The following list gives all the information as to maximum wind pressures that I have been able to collect :—

Maximum Wind Pressures.

	Per sq. foot.
Williamstown Old Observatory, Victoria, 1854, Ostler's anemometer...	35 lbs.
Sydney Observatory, N.S.W., 65 feet above ground	115 lbs.

	Per sq. foot.
Glasgow Observatory, 1879	25 lbs.
Glasgow Observatory, maximum, according to Trantwine	55 lbs.
Liverpool Old Observatory, maximum, according to Mr. Russell	71 lbs.
Philippine Islands, instrument broke at ...	103 lbs.
North America, locomotive blown over, pressure necessary	93 lbs.
Great Britain, maximum, according to Rankine	55 lbs.
Maximum in violent hurricane, according to Molesworth	49 lbs.
Liverpool Observatory, 1868, sudden gust, according to Hartnup, Ostler's anemometer	80 lbs.
During five years at Greenwich Observatory, maximum	41 lbs.

In this list what strikes one most is the amazing discrepancy which occurs between the records from New South Wales and Victoria, and, unfortunately, it is with these figures that we have mainly to do. It is quite incredible (recollecting that 50 lbs. pressure means a violent hurricane) that the wind should have attained in New South Wales a force 80 lbs. per square foot greater than that ever experienced in Victoria. It must be concluded, then, that anemometrical measurement is unsatisfactory; and most persons will agree with the verdict of a competent judge when he says "that anemometry, for engineering purposes, is in a chaotic state."

Even assuming, however, that storms have occurred giving a pressure of over 100 lbs. per square foot, such storms must be looked upon as highly phenomenal—of such rare occurrence and so limited in area, that the chances of any particular structure meeting such a gale are extremely remote, and therefore all consideration of such pressures may reasonably be neglected.

The maximum assumed in Great Britain for engineering purposes appears to range from 40 to 60 lbs., and most important structures are designed to meet such a force. In Victoria the Werribee viaduct is designed for a pressure of 50 lbs., and if we take a force varying according to the considerations mentioned hereafter of from 50 to 70 lbs. per square foot, we shall get as near a reasonable solution of the first point in connection with the matter as we can expect to attain.

Second. *The nature of the situation as to shelter or otherwise.*

This point may be dismissed in a few words. A tower or chimney upon a high, bare hill, a lighthouse on the sea-coast, a railway-bridge swung high across an open ravine, will all require that the maximum be fixed higher than if the structure were in a hollow, or sheltered by hills, timber, or adjacent buildings. This point can only be settled from an examination of the locality of the proposed structure.

Third. *The height of the structure above the ground and the nature of its construction.*

As the wind approaches the ground it diminishes in velocity; the more uneven the surface and the greater the obstacles, the more is the velocity interfered with and lessened. To what height and to what degree this interference extends is unknown. No experiments, I believe, have ever been made for the purpose of ascertaining this. We must conclude, however, that close to the ground this interference is very considerable, and upon this supposition we can explain the reason why chimneys and buildings notoriously unfit to stand a pressure of 20 lbs. or less are still standing, although gales of greater force than that have occurred since their erection.

Structures in connection with this part of the subject may be conveniently divided into two classes—

1. Those which extend from the ground continuously upwards, as a factory chimney.
2. Those which extend horizontally at a constant height above the ground, as a girder bridge.

If in the case of the first we assume 60 lbs. as the maximum for the locality, it is evident that this will decrease as it approaches the base, and that it would be permissible to reduce this force; or, if we maintain it for the purposes of calculation, it should be recognised as allowing ample margin as factor of safety.

In the second class of structures, however, the maximum would have to be taken as practically uniform all over the surface exposed, allowing nothing as factor of safety.

Fourth. *The value and use of the structure, and whether its failure would involve loss of life or damage to adjacent property.*

The greater the value of the structure, the greater will be the necessity of ensuring its safety. It evidently would not be true economy to build an ordinary house-chimney to withstand a pressure of 50 or 60 lbs. to the square foot, although it would be so in the case of a large factory chimney. The failure of the latter would not only be a great loss of valuable property, but would, in all probability, occasion stoppage to works, damage to adjacent property, and possibly loss of life.

The structure, however, in which every condition is present, demanding the utmost degree of safety, is that of a large railway viaduct. In this the full maximum for the locality should be adopted without limitation of any kind.

Having now considered the manner of deciding what wind pressure to adopt as the maximum to be provided for in any proposed structure, I will proceed briefly to examine the means of making this provision. All structures in this connection may be placed in three classes, of which the following are types—viz.—

1. A factory chimney.
2. A roof.
3. A girder bridge.

1. *A factory chimney.* The stresses here will be those of a beam fixed at one end and loaded uniformly. The resistance will be due to the weight of the material multiplied by half the diameter of the building.

It is convenient in building structures of this kind to carry up the walls in lengths of different thickness, diminishing by half a brick at each change. The weakest points will then be the joints at which these changes take place. To these points only is it necessary to give our attention.

In a brickwork chimney, where the resistance is obtained from the material itself, and not from a comparatively trifling and independent system, as in the case of a girder bridge, it will be undoubtedly of the utmost importance that the material be disposed of with the greatest economy, and duly proportioned to meet the stresses it will have to bear. If the whole chimney, except one joint, will stand a pressure of 60 lbs. per foot, but that joint only 45 lbs., then every bit of the material going to strengthen that chimney beyond 45 lbs. is absolutely wasted.

The largest chimney, and the fourth highest building in the world, is Tennant's, in Glasgow. It rises 435 feet above the ground, and it might have been expected that the design would have been beyond criticism. The following figures, taken from *Rankine's Applied Mechanics,* will show that this is not the case :—

Height above ground.	Resistance of joint.
435 ft.	——
350 ft.	77 lbs.
210 ft.	55 lbs.
114 ft.	57 lbs.
54 ft.	63 lbs.
0	71 lbs.

55 lbs. is therefore the resisting strength of that structure, and all the material going to raise the strength of the other parts beyond this might have been saved.

The most satisfactory way to design a building of this kind is by a diagram. I have prepared one for a round brick chimney, 200 feet high, 20 feet diameter at bottom, and 10 feet diameter at top, by way of illustration. Figures have been adopted throughout to facilitate computation. The weight of brickwork is taken as 112 lbs. per cubic foot, the maximum wind pressure at 56 lbs. per square foot on a flat surface giving 28 lbs. per foot for the surface of the chimney. The tensile strength of the brickwork has been neglected, and the effective width has been taken from the centre of the chimney to the centre of the wall. The stresses and resistance have been calculated at intervals of 20 feet, and plotted to a scale of 20 feet to an inch vertical, and 800 foot tons to an inch horizontal.

The red line, showing a curve almost parabolic, is the curve of moments due to wind pressure. Had the building been of uniform diameter the curve would have been truly parabolic.

Then, starting from the top with a 9-inch wall, the blue line represents the resistance due to that, crossing the curve of moments about half way. The orange line shows the resistance of a 14-inch wall starting at 120 feet elevation, and crossing the curve of moments at about 20 feet from the ground; and the green line shows the resistance of an 18-inch wall starting at 40 feet elevation and running to the surface outside of the curve of moments altogether.

The compound curve due to the use of these three thicknesses of brickwork gives a line of resistance which is equal to a wind pressure of 76 lbs. per square foot, or 20 lbs. beyond the maximum assumed, and varying from this at no point more than 7 lbs., thus showing the designer, in the clearest way, the proper thickness of brickwork to be used, and at what points to change from one thickness to another.

The consideration of the wind pressure in connection with roofs and bridges must be left for treatment in another paper.

Art. IV.—*Evidences of a Glacial Epoch from Kerguelen's Land, being Comments upon the "Challenger" Reports.*

By Mr. G. S. Griffiths.

[Read 13th May, 1886.]

The occasion of adding to our library two volumes which summarise the labours of the "Challenger" expedition, affords me an opportunity of describing some discoveries in Kerguelen's Land which tend to throw some more light upon the nature of the climate of this hemisphere in the past.

Kerguelen's Land is a small island placed upon an isolated submarine plateau about 450 miles long and 250 miles wide, situated in 49 deg. S., 68 deg. W. Its coast-line is broken on every side by deep sounds, and two ranges of comparatively lofty mountains divide the limited territory between them. The western range has a mean height of about 3400 feet, and an extreme one of 6120 feet. The eastern system has a mean of 3000 feet. The mountains appear to be a series of extinct volcanoes, but the west coast has one still active, and it is surrounded by hot-water springs, petroleum springs, and mineral pitch deposits, all phenomena characteristic of the later stages of expiring vulcanicity. The entire island is built up of horizontal layers of lava, clay, and coal. The lava beds are from 10 to 20 feet in thickness, and these are separated by thinner beds of the other materials named. There are also with these abundant deposits of fossilised pine trees, and some of the trunks of these trees are two feet in diameter. These horizontal strata enwrap the bases of numerous domes and peaks of grey phonolite, an older volcanic rock. This phonolite is also disposed horizontally, and the peaks are but the remnants of more ancient plateaux which had already been weathered down into so many rugged outliers before the last series of lava outflows had commenced to flow. The sea cliffs, being everywhere built up of hard and soft layers, have weathered into a series of well-marked ledges, which ascend from the beach to the mountain tops in natural staircases.

The island is situated in the path of the wet westerly winds which blow strongly and with few interruptions.

The higher range is also the weather range, and its crests intercept the low-travelling clouds. These snow-capped heights wring from the passing winds their moisture, which is deposited, at the greater altitudes, in snow, and at the lesser in sleet and rain, and the winds then pass on to the lower hills at the eastern and leeward end of the islands, diminished in force and in a comparatively dry and cloudless condition, and in descending they may become relatively warm. In consequence of these circumstances the leeward range, although 3000 feet in mean altitude, is always free from snow in summer; while the weather range, with a mean altitude only 400 feet higher, is covered with perpetual snow, which unloads itself down the valleys in great glaciers. These latter do not anywhere reach the coast, and their terminal faces are but rarely even visible from the sea-shore, owing to the thickness of the atmosphere in their vicinity, and to their distance inland.

The interesting feature in relation to these glaciers, and the one to which I desire more particularly to call your attention, is that, whereas they are to-day confined to the higher valleys of the higher range, there are abundant and indisputable* evidences that the whole island down to, and even below, the sea-level, was buried under ice at a comparatively recent period. The furrows of glaciers are seen wherever the island has been explored. The lower hill-tops, still bare and barren, have been cut down by travelling ice, which has planed them smooth exposing clean-cut, horizontal sections of the geodes of the amygdaloidal rocks. Each shelf of the basalt stairs has its striæ, and the lower valleys are scratched and scraped and smoothed by glaciers which have since disappeared.† Every harbour is an ice-cut fiord. Royal Sound has its entrance barred by a sill but 15 fathoms deep, whereas its floor falls within until, near to

* *Challenger Reports*, p. 348. † *Challenger*, p. 356.

its head, there is a depth of from 70 to 100 fathoms. Its numerous islets are all flat-topped, having been planed down to a common shape and level; and these truncated islets have their surfaces covered with erratics. *

Thus we see that the island presents every indication of its having been more extensively ice covered not long since, and the great changes in the climate of Kerguelen's Land indicated by the existence of forests of fine timber at one time, and by the occurrence of an ice-sheet enveloping the entire island at another, help to confirm the conclusion which has been drawn from the facts of Australian geology that the southern hemisphere has had its secular climatic mutations. Thus a large question at issue is being gradually reduced to the lesser one, of whether the temperature oscillations were local, and due to local causes, or universal in obedience to some less obvious and more cosmic influences.

There are some other interesting features connected with this island.

The flora of the island is poor. The ranker vegetation dies out at an altitude of 300 feet, but flowering plants cover the hill sides up to 1000 feet, and they exist in patches where there is shelter up to 1300 feet.

Under the protection of the herbage a few species of inactive, wingless flies, gnats, and moths crawl, their habits and structural modification exhibiting an interesting relation to their small, isolated, and boisterous habitat. The higher fauna is restricted to birds and seals. The climate is typically insular, with the small annual range of 9 degs., the mean summer temperature being about 45° F., and the winter 36° F. Even in the depth of winter the thermometer at the sea-level rarely falls below the freezing point, and the snow never lies on the low ground for longer than two or three days.†

When we remember that the weather range is perpetually snow-covered at a small altitude, and that Heard Island, but three hundred miles to the southwards, is glacier-covered to the water's edge, we must be struck with the circumstance that the Kerguelen vegetation is perennial, and not annual, and that it is not only evergreen, but that some of its plants were observed by Ross to be in flower at midwinter.‡

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* *Challenger*, 332; *Ross*, Vol. I., p. 69. † *Challenger Reports*, 354.

‡ *Ross*, Vol. 1., p. 86, and *Challenger Reports*, p. 355.

There are some other interesting generalisations to be noted in connection with the "Challenger's" Antarctic trip. It is believed that in winter the sea to the south of 63° is frozen over.* At all seasons of the year a thin wedge-shaped layer of ice-cold water projects northwards to 54 deg. south, covered by a skin of warmer water. The thickness of a single season's ice is believed to be about three feet,† whereas in the Arctic it is six feet. The icebergs are stratified horizontally, the oldest and lowest strata being the thinnest, as the result of vertical compression and horizontal expansion. But the ice possesses a fine cleavage lamination,‡ the faces of which lie at right angles to the bedding. The enormous outward thrust operating from the pole, squeezing the ice-sheet outwards at the rate of a quarter of a mile per annum, will account for the cleavage, and its occurrence under such circumstances affords geologists a striking confirmation of the correctness of the theory which has been advanced to explain rock cleavage.

Two important features of the Antarctic Ocean have been brought to light.

Firstly, the nature of the sea-bed changes as we go southwards. It is barred with different materials, which, disposed in three concentric zones, encircle the polar regions, and, similarly, the ocean water is banded with three distinct micro-faunal regions, corresponding in their respective positions with the series of deposits accumulating below. Between 64 deg. and 66 deg. S. we have the blue muds, with pebbles and decomposed shales, which elsewhere always indicate land proximity. In this deposit, then, we have an unexpected testimony to the existence of a land area around the Antarctic Pole. From 64 deg. to 53 deg. S. the bottom consists of diatom ooze and a little mineral matter derived from the overlying ocean, which supports enormous swarms of diatoms and a smaller number of radiolarians.

From 53 deg. to 47 deg. S globigerina ooze predominates, and north of 47 deg. south red clay with such deep-sea deposits of whales' ear-bones, sharks' teeth, and manganese nodules, as are indicative of clear still water.§

Singular testimony to a past cold epoch was found at two stations in 38 deg. S, within the Pacific, in the shape of small granite erratics found far from land.‖

* Rep. p. 418. † Rep. p. 430. ‡ Rep. 432.

§ *Challenger Reports*, p. 813. ‖ *Reports*, p. 435.

These erratics could have reached these localities only by iceberg transport, and excepting during a cold epoch icebergs would be melted long before they could approach so near to the equator.

The expedition noted as did Ross that icebergs were very scarce to the west of 80 deg. E, and from this circumstance they judged that much Antarctic land did not exist on that meridian. This should indicate the course for the forthcoming south polar expedition to take.* And in connection with Antarctic expedition the small downward range of the thermometer at Kerguelen warrants us in hoping that the Antarctic climate is milder and less trying to explorers than that of the Arctic. Though the summer be chillier than that of the north, the winter is less severe. A self-registering thermometer exposed for three seasons in the Georgias never sank below —5°

At the Horn the winter temperature is very little lower than that of Greenwich, although the summer temperature is much lower, while the mean range is much less.†

Having added to our library these valuable volumes of the "Challenger" Reports, it appeared to me that the members of this Society might be interested enough in the undertaking to care to listen to these rough memoranda relating to a part of the cruise.

ART. V.—*Plants collected in Capricornic Western Australia, by H. S. King, Esq., and recorded by Baron Von Mueller, K.C.M.G., M. & Ph.D., F.R.S.*

[Read 13th May, 1886.]

DURING the last year survey-operations were carried on between the Lyons- and Fortescue-Rivers, as well as on and near the Upper Ashburton-River, by Mr. H. S. King, under the direction of the Honourable John Forrest, C.M.G., F.L.S., F.R.G.S.; and on this occasion again, through the influence of the enlightened Minister of Lands and Surveyor-General of the colony, specimens of the plants, met

* *Report*, p. 430; M'Cormack's *Antarctic Voyage*, Vol. 1, p. 166.
† *Challenger Reports*, p. 877.

during the survey, were secured, and through Mr. Forrest's liberality placed at my disposal. As the region, from which this collection was obtained, is phytogeographically a most interesting one, the tropical and extra-tropical species of the western part of the Australian continent largely meeting in the tracts of country traversed by Mr. King, it is my purpose to enumerate in these pages the species obtained, by which means new localities of many rare plants will be placed on record, and some new forms will become elucidated, while by these means also some further impetus in various parts of Australia will be given perhaps for utilising the splendid opportunities, when surveys are effected in new districts, to enrich collaterally also our knowledge of the native vegetation and the resources connected therewith.

Cleome tetrandra, Banks; var. grandior. Taller and more robust; leaflets broader; style longer, very thin and curved; stigma not dilated; fruit more distinctly stipitated.

Cleome viscosa, Linné. Fruit always without any stipes; seeds smaller and darker coloured than those of the preceding species. The variety grandiflora, noted by Bentham, is in the third supplement to the *Systematic Census of Australian Plants* raised to specific rank under the above appellation. Some of the shorter filaments are remarkably thickened near the summit, almost as in the American species of the section Physostemon. The ripe fruit of C. grandiflora remained hitherto unknown.

Byblis liniflora, Salisbury. Fully a foot high.

Drosera Indica, Linné.

Tribulus platypterus, Bentham.

Triumfetta chætocarpa, F. v. M.

Sida lepida, F. v. M.

Abutilon longilobum, F. v. M. A variety with leaves less elongated and more definitely star-hairy, with calyces not always cleft beyond the middle, and with the petals usually longer.

Hibiscus trionum, Linné.

Hibiscus Goldsworthii, F. v. M. The specimens of this highly ornamental plant show larger leaves with longer lobes, also capsules of only about half the length of the calyx.

Gossypium Sturtii, F. v. M.

Gossypium Robinsonii, F. v. M.

Gossypium australe, F. v. M.

Brachychiton platanoides, R. Brown. Passes also in Eastern Australia just beyond the tropic of Capricorn.

Euphorbia Careyi, F. v. M. Fruit not fully ⅛th inch long, three-lobed globular; seeds trigonous-ovate, dark-brown, minutely scaly-hairy, destitute of any appendage.

Euphorbia Drummondi, Boissier. Specimens over a foot broad.

Securinega Abyssinica, A. Richard.

Dodonaea petiolaris, F. v. M. Sepals five, oblong-lanceolar, ⅛th inch long. Fruit roundish-ovate in outline, about 1⅓ inch long and ¾ inch broad, glabrous, almost vesicular, finely veined, short-pointed at the summit, the three longitudinal expanding membranes much narrower than the cells of the fruit, confluent with each other at the upper extremity, not forming lobes on the base; ripe seeds unknown. This species was also found near the Finke-River by Rev. H. Kempe, and near the Lachlan-River by Mr. Josephson.

Dodonaea pachyneura.—Branchlets slightly angular; leaves narrow-lanceolar, entire, gradually attenuated into a slender petiole, prominently penninerved, as well as the branchlets densely beset with glandular dots; sepals broadly semi-lanceolar; pedicels usually two or three together, as long as, or somewhat longer, than the fruit, very thin; capsules three-celled, somewhat viscid, the expanding membranes broader than the cavities, gradually narrowed to near the very short septa, each thus almost including the appertaining roundish-turgid cell, and giving each of the three partitions of the fruit an oblique rhomboid-ovate shape, the upper margin of the membrane more truncate, the lower more rounded; septa not fully half as long as the cells and seceding with them.

The whole plant sticky from minute glandular prominences. Leaves flat, dark-green, on the only specimen obtained 1—1½-inch long, above the middle about ¼-inch broad, some faint denticulations occasionally developed at the margin. Sepals nearly 1-10th inch long. Staminate flowers not obtained. Partitions of fruit broader than long, their membranes very divergent, conspicuously veined, rather obtuse at the terminating angle; stipes very short. Style and ripe seeds not available.

From D. platyptera, the nearest allied species, this new one recedes in greater viscidity, in narrower downward much more attenuated leaves, with singularly prominent and more copious nerves, as well as in the extension of the fruit-membranes along the summit and base of the cells, and further in the remarkable smallness of the septa.

Polycarpaea Indica, Lamarck, var. obtusiflora. The plants only about two inches high, but much branched and profusely flowering; sepals rather blunt; capsule exceedingly short. Perhaps this variety will, under the above name, have to be raised to a specific position.

Polycarpaea longiflora, F. v. M.

Mollugo trigastrotheca, F. v. M.

Trianthema crystallina, Vahl.

Trianthema pilosa, F. v. M.

Achyranthes aspera, Linné. Reaches the most northern regions of New South Wales (Fawcett).

Amarantus pallidiflorus, F. v. M.

Ptilotus obovatus, F. v. M.

Ptilotus exaltatus, Nees.

Ptilotus alopecuroides, F. v. M.

Ptilotus helipteroides, F. v. M.

Ptilotus fusiformis, Poiret. Mr. Moritz Holtze found this plant also near Port Darwin.

Ptilotus axillaris, F. v. M.

Gomphrena canescens, R. Brown.

Gomphrena Maitlandi, F. v. M. Specimens with flower-heads partially axillary.

Gomphrena platandra, F. v. M. Under this new name a species is defined, which from the only other Australian congener with filaments dilated and at the summit bidenticulated, namely G. conica, differs in diffuse growth, in shorter leaves, in unchanging globular flower-heads supported by two floral leaves, in larger bracteoles of greater length than the calyx, and in the rosy colour of the sepals. From the following species it is distinguished in broader leaves, in much larger and never elongated flower-heads, as well as in the toothed apex of the filaments.

Gomphrena conferta, Bentham. This was found by the Hon. J. Forrest also on the Yule- and Shirlock-Rivers. There likewise G. tenella occurs, but with finally spicate inflorescence.

Alternanthera triandra, Lamarck.

Codonocarpus cotinifolius, F. v. M.

Isotropis atropurpurea, F. v. M. Fruit about $\frac{3}{4}$-inch long; seeds kidney-shaped, $\frac{1}{8}$-inch long, prominently reticulated.

Gastrololium grandiflorum, F. v. M.

Crotalaria Novæ Hollandiæ, De Candolle.

Crotalaria Cunninghami, R. Brown.

Crotalaria dissitiflora, Bentham.

Crotalaria medicaginea, Lamarck.

Lotus australis, Andrews. Now also known from New Caledonia, the New Hebrides and Japan.

Psoralea leucantha, F. v. M.

Indigofera monophylla, De Candolle.

Tephrosia purpurea, Persoon. The silky variety obtained; also what seems a form with very narrow leaflets, but gathered without fruit.

Sesbania grandiflora, Persoon.

Clianthus Dampieri, Cunningham.

Swainsona Macculochiana, F. v. M.

Swainsona Kingii. Slightly hairy, soon glabrous; stipules very large, semicordate-lanceolar; leaflets of each leaf in two to three rather distant pairs, somewhat glaucous, nearly lanceolar, on very short stalklets, not darker above; peduncles almost capillary, fully as long as the leaves, bearing at and towards the upper end two to four rather small flowers; pedicels much shorter than the calyx, not much longer than the small lanceolate-linear ciliate bracts; lobes of the calyx narrow-lanceolar, about as long as the hemi-ellipsoid tube; upper petal considerably longer than the others, cordate-orbicular, with two faintly prominent erect lines extending from the base to beyond the middle; lower petals acute, not twisted, nearly as long as the blunt lateral petals; style towards the summit anteriorly short-bearded; ovary slender, glabrous. Between the Gascoyne- and Fortescue Rivers; H. S. King, Esq.

Branches slender; stipules mostly about $\frac{2}{3}$ inch long; leaflets $\frac{1}{3}$—$\frac{1}{2}$ inch long, but occasionally the terminal one exceeding the others in size; calyces nearly $\frac{1}{4}$ inch long. Lamina of upper petal measuring fully $\frac{1}{3}$ inch, its stipes tender-membranous; lateral and lower petals violet-coloured towards the summit. Anthers narrow-ellipsoid. Style but slightly curved. Stigma very minute. Fruit not obtained.

This species may systematically be approximated to S. oroboides, which it resembles often in foliage; but the stipules in the last-mentioned congener are minute, the peduncles and pedicels thicker, the calyces permanently hairy, while the petals are less unequal in length, the lateral two broader, the lower two blunt, the upper having very prominent callosities, which terminate almost truncately just above the stipes, the style is more rigid and the ovary downy; in fruit S. Kingii may also prove very different. The great development of the stipules, which exceed in size much any of the leaflets, separates this species at once from all others.

Glycine sericea, Bentham. Found as far north as the Mulligan-River by Mr. Cornish.

Cajanus cinereus, F. v. M.

Petalostylis labicheoides, R. Brown.

Cassia venusta, F. v. M.

Terminalia circumalata, F. v. M. This is the doubtful Alectryon canescens (D. C. Prodr. I, 617), which was probably described from specimens gathered during Captain Baudin's expedition, and thus likely on the west-coast, not in Eastern Australia, as so long was supposed. I owe an original specimen to the kindness of the illustrious Alphonse de Candolle.

Pimelea ammocharis, F. v. M.

Hakea lorea, R. Brown. Collected on the Upper Flinders-River by Mr. Dugan.

Grevillea Wickhami, Meissner.

Cucumis Chate, Linné.

Melothria Maderaspatana, Cogniaux. A variety with sessile leaves, precisely of the form peculiar to those of M. amplexicaulis, but with the not pedunculate staminate flower-fascicles, with the sphærical fruit and with the unmargined seeds of M. Maderaspatana.

Brachycome iberidifolia, Bentham.

Pterocaulon sphacelatum, Bentham.

Helipterum floribundum, De Candolle.

Helipterum Humboldtianum, De Candolle.

Helipterum roseum, Bentham. Eastward to Georgina-Range (Harper).

Podolepis rugata, Labillardière.

Calocephalus multiflorus, Bentham. A form with broader leaves.

Eriochlamys Kappii, F. v. M.

Flaveria Australasica, Hooker. Traced southwards to the Bogan (Wuerfel).

Lobelia humistrata, F. v. M.

Lobelia heterophylla, Labillardière.

Scaevola ovalifolia, R. Brown.

Cynanchum floribundum, R. Brown.

Ipomœa Muelleri, Bentham.

Evolvulus linifolius, Linné.

Breweria rosea, F. v. M. A variety with smaller flowers, also a state of this plant with grey vestiture.

Solanum phlomoides, Cunningham.

Nicotiana suaveolens, Lehmann. A minute variety.

Mimulus gracilis, R. Brown. Mr. St. Carey found this also on the Lyndon-River; the allied M. prostratus we have now also from near Everard-Range (Giles), the Wimmera (D'Alton) and Dandenong (Walter).

Stemodia grossa, Bentham.

Stemodia viscosa, Roxburgh. A form with much elongated pedicels.

Buechnera parviflora, R. Brown.

Pollichia Zeilanica, F. v. M.

Heliotropium undulatum, Vahl. This occurs also on the Finke-River, according to collections from the Rev. H. Kempe.

Clerodendrum lanceolatum, F. v. M.

Chloanthes paniculata, F. v. M.

Eremophila maculata, F. v. M.

Eremophila Forresti, F. v. M.

Eremophila leucophylla, F. v. M.

Eremophila Fraseri, F. v. M. Both varieties gathered of this species, the one with short roundish leaves and the other with elongated lanceolar leaves; the first mentioned is easily mistaken for E. rotundifolia.

Cyperus ixiocarpus. Stem cylindrical, finely streaked-furrowed, smooth; floral leaves three or four, the two longest of these generally much surpassing the inflorescence, channelled towards the base, thence upwards compressed-cylindrical and gradually much attenuated, smooth, one or two of the floral leaves very abbreviated; primary peduncles several, almost umbellate, unequal in length, smooth, not prominently angular; secondary peduncles almost umbellately crowded, very thin, each supported by a diminutive, narrow, bract-like leaf; spikelets almost sessile, corymbous-umbellulate, with a linear-lanceolate one-nerved glume-like bract at the base, generally but few of the spikelets in each of the umbellules; racheoles flexuous, simply angular, not or scarcely membranously dilated, bearing six to thirteen florets, the latter somewhat remote from each other, the two or three uppermost sterile; glumes (floral bracts) pale-brownish, almost cymbiform-ovate, mucronulate, strongly five- to seven-nerved, the middle nerve keel-like; stigmas three, about as long as the style; fruits obovate-trigonous, black, shining, viscid, apiculate, somewhat more than half as long as the glumes.

This remarkably handsome species had been already in 1882 collected on the Gascoyne-River by the Hon. J. Forrest during his trigonometric surveys there. All the specimens obtained are devoid of roots and radical leaves.

In vain have I endeavoured to identify this Cyperus with any of the species described by Kunth, Steudel, Boeckeler and Clarke. But this task is difficult as regards a genus containing several hundred well-marked species, irrespective of their varieties. Our plant is however traceable to a position near the tropical American C. viscosus; but the spikelets are not capitately clustered, nor are the florets closely imbricated; while the glumes are more scarious, evidently viscid, stronger nerved and more prominently keeled, the fruits moreover being somewhat longer, more sticky, less pyriform, nor covered by a grey pellicle.

Setaria verticillata, Beauvois.

Panicum pauciflorum, R. Brown. The fastigiate variety. This grass was obtained near Short's Range by J. Macd. Stuart.

Eriachne obtusa, R. Brown.

Eriachne aristidea, F. v. M. Specimens with leaves somewhat hairy outside.

Eriachne glauca, R. Brown. The leaves on the inner side towards the base sometimes hairy.

Eriachne ovata, Nees. A small-flowered variety was found by Mr. H. Stuart Carey on the Fortescue-River.

Triodia Mitchelli, Bentham. A variety with contracted panicles and with particularly large spikelets, the middle lobe of the flowering glume attaining a length of fully a quarter of an inch. Only the inflorescence in Mr. King's collection, but this as well of pale as of purplish-darkish colour.

Pappophorum commune, F. v. M.

Eragrostis speciosa, Steudel. Grain ovate, three or four times shorter than the flowering glume. Mr. Ch. Winneke brought a dwarf form of this grass from Eyre's Creek.

Eragrostis eriopoda, Bentham. Collected also near Charlotte-Waters by Mr. E. Giles, and between the Lachlan- and Darling-Rivers by Mr. R. Bennett.

Eragrostis tenella, Beauvois.

Chloris scariosa, F. v. M.

Astrebla pectinata, F. v. M.

Andropogon Australis, Sprengel. Along with the normal form a variety, remarkable for its quite pale vestiture.

Andropogon Gryllus, Linné.

Anthistiria ciliata, Linné, fil.

Anthistiria membranacea, Lindley.

Erianthus fulvus, Kunth.

Cheilanthes tenuifolia, Swartz.

Cheilanthes vellea, F. v. M.

Mr. King's collection contains also another Stemodia, which was not known from Australia before, and seems also unrecorded from Southern Asia or elsewhere. I have designated it specifically with the finder's name, but in absence of fruit the plant cannot be described satisfactorily, nor be placed sectionally into the genus, though it would likely merge into Limnophila. The plant is glabrous; the leaves are opposite and remain well green in drying; the upper, (which alone became available,) are linear or narrow-lanceolar and not distinctly denticulated; the flowers are nearly sessile, solitary in the axils; the bracteoles narrow-lanceolar, much shorter than the calyx; the three outer segments of the latter are $\frac{1}{2}$—$\frac{2}{3}$-inch long, of herbaceous texture, almost lanceolar, the two inner very considerably narrower, but nearly as long; the corolla is glabrous, except inside near the base, and a little hairiness occurs also on the upper lobes; the tube is broadly cylindrical, almost as long as the labia; the upper lip is bifid, thus producing orbicular-cuneate lobes; the lower lip is bluntly 3-dentated; the filaments are conspersed with stipitate minute glands; the anthers have their cells parallel but almost disconnected, and are fixed from a dorsal small protuberance to the filament; the style is glabrous; the stigma divided into two semi-orbicular lobes; the ovary ovate-conical, glabrous and pointed.

ART. VI.—*On the Possibility of the Force Producing Gravitation not acting directly on every Particle of a Planet.*

BY T. WAKELIN, B.A.

[Read 10th June, 1886.]

ART. VII.—*Stability of Structures in regard to Wind-Pressure.*

PAPER 2.—BRIDGES.

BY FREDK. A. CAMPBELL, C.E.

[Read 10th June, 1886.]

WIND-PRESSURE in connection with bridges assumes, for the engineer, its most important aspect. This is especially the case when the bridge is of large dimensions, and is used for railway purposes. Such a type will now be considered—viz., a large iron railway bridge upon iron columns.

Still following the method suggested in the first paper, it will be necessary to fix the probable maximum for the locality of the structures. As these are usually in exposed situations, and as everything demands the highest state of security, it would be wise to adopt a high maximum for the purpose of calculation.

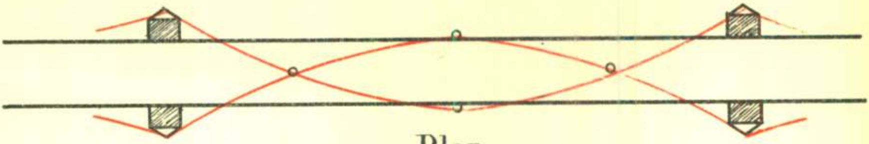
From 50 to 70 lbs. per square foot, the latter where the position is peculiarly exposed to high gales, would appear to be suitable pressures to take for this purpose.

The amount of force exerted upon one span of such a bridge will depend upon the area of the surface of the girders exposed, the area of the columns in the pier, the vertical area of a train passing over, and the height of the girders above the ground.

If the girders be of web construction, the pressure can readily be found; but if, as will probably be the case in a large structure, the girders be latticed, a little more difficulty exists.

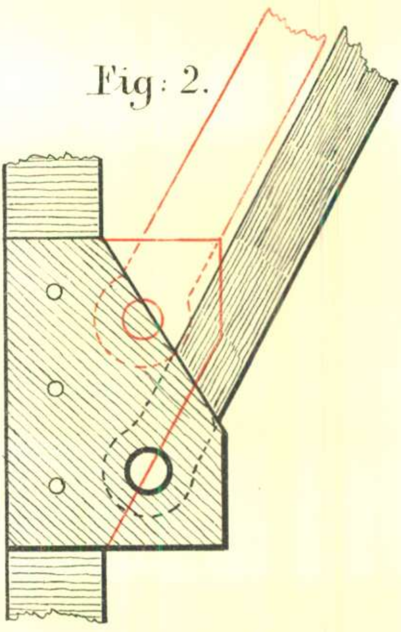
After the failure of the Tay Railway Bridge a commission of eminent engineers drew up a report upon the subject of wind-pressure on bridges, and the following method was recommended by them for determining the pressure upon lattice girders:—

Fig: 1.



Plan

Fig: 2.



Scale 1½ Inches to 1 foot

The maximum pressure for all railway bridges to be 56 lbs. per square foot, but this to be multiplied by four as a factor of safety; where stability alone is concerned, to be multiplied by two.

The full pressure to be taken from the level of the rails to the top of a train passing over, and the full pressure for all the area of girder exposed below and above this.

For all the vertical surface of the leeward girder below level of rails and above top of train the pressure to be taken as follows:—If the area of the open spaces does not exceed two-thirds of the whole area within outline of girder, the pressure to be taken at 28 lbs. per square foot. If such area be between two-thirds and three-fourths, the pressure to be taken at 42 lbs.; and if over three-fourths, to be taken in full.

The members of the commission were Messrs. Hawkshaw, Barlow, Armstrong, Stokes, and Yolland.

It is not stated whether the method adopted of determining the pressure upon the leeward girder is obtained from the results of experiments or not, but it is evident that without such data it is impossible to say in what manner and to what extent the strength of the wind is interfered with on passing through orifices. This question requires further elucidation.

In event of the spans being of greater length than the passing train, the area of exposed surface of the girders should be taken all round the area presented by the train, not only above and below.

The effect of the wind-pressure upon the columns in low-level bridges is not of great consequence. Where the piers are high, however, it would not be advisable to neglect this force; and in determining it the area should be taken of all the columns in the pier, even although they are placed in a single line at right angles to the bridge, for a very slight deviation of the wind from that line would expose all the columns to its force.

When a bridge of the construction named is destroyed by wind-pressure, the failure is due to one of the following four causes:—

Instability of pier.
Lateral weakness of pier.
Instability of superstructure.
Lateral weakness of superstructure.

1. *Instability of Pier.*—In this case, whilst the various parts maintain their respective positions, the whole pier overturns upon the base of the leeward column.

The overturning moment is the pressure upon the girders, upon a passing train, and upon the piers, multiplied by the distance of the centres of pressure from the foot of the leeward column. The moment of stability is the weight of the portion of the bridge considered, superstructure and piers, and the weight of the passing train, multiplied by the distance at which it acts from the leeward column—that is, half the width of the base of pier. The point in the leeward column to which the width should be measured, lies somewhere between the centre and the outside of that column. It would probably be advisable, however, in all calculations for the purpose of determining the width of pier in any proposed structure, to take the measurement to the centre of the column, except where these are of great dimensions compared to the width of pier.

In connection with the stability of the pier, no allowance need be made for factor of safety; there can be no imperfection of workmanship in the power of gravitation, nor any weakening of material by successive strains. If 60 lbs., then, be considered as the greatest wind-pressure the bridge will be called upon to bear, there is no necessity to make the pier stable under a pressure of 120 lbs. or 180 lbs. There are, however, other forces tending to keep the pier in position, of which no mention has yet been made, and which might act as a set-off to the chance, which is always within the range of possibility, of the structure meeting a gale of greater force than that for which it has been designed. These forces, though not as a rule calculable, are undoubtedly of considerable extent, varying according to the size and construction of the bridge, and the nature of the ground in which the piers have been sunk. First, there is the hold which the columns on the windward side of the centre have upon the ground, or if bolted to brickwork or masonry, the strength of such attachments; and, second, there is the sustaining power of the girders acting as a tie throughout the length of the bridge, for in a structure of some length those portions struck by the most violent gusts will be supported by the whole of the structure experiencing a force less than that necessary to overturn it.

The area over which the very high pressures of wind extend is another point, regarding which information would be of service to the engineer.

In connection with the sustaining powers of the girders, it may be recollected that the portion of the Tay Bridge which fell was deprived of this support; for its girders were above the rail level, and disconnected with those of the remainder of the bridge, which were below rail level. Had the whole of the bridge been of the continuous girder type it might not perhaps have stood, indeed, but it would have been better able to resist the force of the gale which destroyed it.

2. *Lateral Weakness of Pier.*—In this case the pier will fail by each column turning upon its base independently. The overturning moment may be determined in the same way as for the first case. The resisting force is provided chiefly by the bracing between the columns. When these are sunk in the ground additional resistance will be obtained from their strength as semi-beams; when they are bolted to brickwork or masonry, from the strength of the fastenings. In long columns, however, and especially in soft ground, such resistance will be but slight, and as well as that due to the attachments to masonry, might be neglected, &c; but where the piers are short, and the ground strong, this resistance must receive due attention.

It is usual to connect columns at intervals by somewhat massive horizontal strutts. These are intended to give the structure the necessary rigidity under passing loads. These braces are usually of sufficient strength to keep the columns perfectly parallel to one another, but to prevent them turning each on its own base diagonal bracing is requisite. Practice varies as to the design of this bracing. The method most in vogue appears to be two tension bars crossing in the centre of each square formed by the horizontal strutts.

This form is not the best, as from whichever side the wind blows, one-half of the bars—those which slope down from the wind—do no work, or, what is worse perhaps, are exposed to compressive strains.

Again, unless the tension-bars are fixed in position with some initial strain, it is quite possible that a certain distortion of the pier might occur before these tension-bars would exert the necessary resisting force.

A single diagonal strutt might be used where the distance between the columns is not so great as to involve a possible bending of the strutt.

The most satisfactory method would be two strutts crossing, and fastened in the centre where they pass one another. As the stresses in all the braces of the pier will be the same, the proper dimensions for the diagonal braces can readily be determined.

Besides collapsing from the weakness of the bracing, a pier may fail through weakness in the columns themselves; for suppose that the force of the wind, without being strong enough to overturn the bridge, is just sufficient to remove the whole weight from the windward columns, the burden must be borne by the leeward ones. In the case of a pier with two columns only, the leeward column would have to bear the whole weight of one span of the bridge. It would appear to be necessary, then, to design columns so as to meet the compressive strains and tendency to buckle, due to the imposition of such a load.

3. *Instability of Superstructure.*—In this case the girders would fail by overturning upon their bases. The overturning moment will be the wind's force upon the surface of the girder exposed, multiplied by half the height of the girder. The resisting power is in the stability of each girder independently, and the strength of the strutts and ties fastening the two together. This case is very analogous to that of the instability of piers, only as the overturning moment is very much smaller, the means of resisting it present no difficulty. The mode of attaching the girders together differs according to the position of the road and the girders. If the road runs through the girders and the headway is limited, arched braces usually connect the tops; if not, the cross-pieces are straight. When the road passes over the girders they are usually fastened in the same way as the columns of a pier—viz., by horizontal and diagonal braces. In this case, even more than in the other, diagonal strutts would appear preferable to ties, giving a greater rigidity to the superstructure under a passing load.

4. *Lateral Weakness of the Superstructure.*—Although there is not much danger of girders being actually broken by the wind's force, it is quite conceivable that in a long span they might be put into such a state of lateral vibration as would unduly strain, and even inflict damage upon, the structure.

To resist this action, girders of any size are braced laterally. These braces usually consist of a series of tension-rods crossing diagonally between the girders for the full length of the bridge, and fastened to the lower flanges. In very large structures the girders are sometimes braced both top and bottom, and this is theoretically the proper way of dealing with the question—that is, by providing two horizontal webs to the main girders, which act as the booms. Where such a system cannot be adopted, a simple method of steadying and laterally strengthening long spans, would be by two tension-rods arranged as shown by red lines on accompanying diagram, No. 1, thus forming a lateral truss of a very common type. Any sagging in the rods would always assist in keeping a strain upon them. Methods somewhat similar to this have been adopted for suspension bridges, which, of course, are peculiarly liable to lateral oscillation.

Before leaving this part of the subject it might be well to allude to the care which should be exercised in the design of the attachments between the bracing and columns or girders.

This might appear to some an unnecessary piece of advice. It might also be termed a mere truism to mention that the strength of a chain is measured by its weakest link.

But the necessity of recollecting these things is most apparent.

Every day structures are put up in which material and consequently money are sacrificed to obtain a strength which is purely imaginary. It is not a very uncommon thing to find that want of attention to some small detail, results in the destruction of the whole structure. The great Tay Bridge was destroyed mainly from the weakness of the cast-iron lugs. It is the old case, in fact, of the spoiling of the ship for the want of a ha'porth o' tar.

The following is an instructive example, taken from a large iron railway-bridge. It consists of one of the fastenings of the wind bracing to the flange of the girder. It may be strong enough, but it shows material wrongly placed, and want of attention to detail. It is illustrated by diagram No. 2, and the strengths of the various parts are given below. It will be observed that by simply reversing the gusset-plates end for end, as shown in the diagram by red lines, the strength of the weakest part of the system would be increased just twofold. The tensile and shearing strength of wrought-iron is taken at 20 tons per square inch.

Breaking Weights of Different Parts.

Bar by tension	60 tons
Bar by shearing of end	75 tons
Bolt by shearing at centre	91 tons
Gusset-plates, shearing by bolt	120 tons
Gusset-plates, shearing by rivets ...	120 tons
Rivets by shearing	25 tons

In altered Position of Plates.

Rivets by shearing	50 tons

In the next paper I hope to treat of the wind-pressure upon roofs, in connection with which I have been making experiments.

Art. VIII.—*Descriptions of New, or Little Known, Polyzoa.*

Part XI.

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

[Read 8th July, 1886.]

Family Catenicellidæ.

Catenicella gemella, n. sp. Plate I., fig 1.

Each internode consisting of a geminate pair of zoœcia, each pair in the main stem giving origin to two double zoœcia, the one pair continuing the stem directly upwards, the other originating a lateral branch, these branches starting alternately right and left; the lateral branches mostly undivided, but occasionally giving off secondary branches; in the lateral branches, the geminate pairs giving off the next pair alternately from the right and left zoœcium;

mouth large, lofty, straight below. Beneath the mouth a series of 5-7 fenestræ around an area continuous with that of the mouth, depressed at the margin, and slightly bulging centrally; the mouth and fenestrate area encircled by a thick margin; lateral processes large. At each upper angle a small acuminate chitinous process (possibly the mandible of a small avicularium); a minute marginal avicularium at the middle of each lateral process at the extremity of a tube-like mark. A minute sessile avicularium on a slight elevation between the cells; posterior surface umbonate; margin finely sulcate.

Port Phillip Heads, Mr. J. B. Wilson.

This very handsome and remarkable species differs from all hitherto recorded in the constant gemination and peculiar arrangement of the zoœcia. The anterior avicularia are very inconspicuous, and not always apparent, and the avicularian nature of the chitinous point on the upper angle of the zoœcium is doubtful.

Claviporella, n. genus.

Branches springing usually from the summits of the zoœcia of a geminate pair, but occasionally from the sides of single zoœcia. Zoœcia single or geminate; usually a large lateral process on each side above, supporting a large gaping avicularium, occasionally small, altered, or aborted.

This genus is proposed for the reception of *Catenicella aurita* (Busk), *C. geminata* (Wyv. Thomson), and two other species which are now described. It differs from *Catenicella*, chiefly in the peculiar key-hole form of the mouth, and differs from *Calpidium*, in which the shape of the mouth is somewhat similar, in wanting the overarching oral hood of that genus. There are also several (usually four) blunt processes in the neighbourhood of the mouth. The species are all very small.

C. pulchra, n. sp. Plate I., fig. 2.

Zoarium very small; branches originating either from the summits of geminate zoœcia or from the sides of ordinary zoœcia. Zœocia vase-shaped, with usually a wide lateral process on each side, turned slightly forwards, and supporting a gaping avicularium; mouth narrow, with the oral sinus very narrow and with a tumid border; two blunt, mamilliform processes on each side of the mouth; a central, vertically elongated pore, in the front of the zoœcium; the rest of the surface papillose, with the papillæ usually larger in the neighbourhood of the central pore; posterior surface smooth.

Port Phillip Heads, Mr. J. B. Wilson.

At once distinguished from the other species by the smaller and narrower zoœcia. The oral sinus has a slightly raised border. On each side of the mouth are constantly two blunt, hollow processes. It is the only species in which I have seen the branches originate from the sides of zoœcia.

C. imperforata, n. sp. Pl. I., fig. 3.

Zoarium small; branches originating from the upper extremity of each of the cells of a geminate pair. Zoœcia, except at a bifurcation, single, broadly vase-shaped; a wide gaping avicularium (frequently differing in size and sometimes wanting) at each upper angle; mouth rather wide, oral sinus small, and with a tumid border; two mamilliform processes on each side of the mouth; front papillose, usually a few of the papillæ towards the centre larger, and probably when worn forming small pores, but there is no proper central pore. Posterior surface smooth. Oœcia galeate tubercular, either surmounting the terminal zoœcium of a branch or one in its continuity; in the former case the upper outline rounded, in the latter a wide, gaping avicularium at each upper angle.

Port Phillip Heads.

Closely allied to *C. aurita*, but I think specifically distinct. In *C. aurita* there is always a distinct, large pore in the front of the zoœcium, usually (but not always) surrounded by a ring of fenestræ. I have added figures of two forms of *C. aurita*, with only a single central foramen; in one the lateral avicularian process is enormously developed on one side of each zoœcium.

Family MEMBRANIPORIDÆ.

Amphiblestrum bursarium, n. sp. Plate II., fig. 2.

Zoarium encrusting. Zoœcia quadrate, elongated, rounded above, separated by thick, crenulated margins; about two-thirds of the area filled in by a calcareo-membranous lamina;

aperture hollowed below; mouth situated at the extreme upper end; a short, stout, mamilliform process on each side above. Avicularium at the upper part of a special cell, the mandible directed upwards, narrowed below, broad and rounded above, the narrow chitinous band in its margin minutely beaded or crenulated.

Sorrento, Rev. Dr. Porter.

At once distinguished by the membrano-calcareous lamina, the mamilliform process on each side of the mouth, and especially by the peculiar avicularium, the mandible of which shuts down like one side of a clasp-purse. It approaches the genus *Biflustra.*

Family MICROPORIDÆ.

Thairopora Jervoisii, Hincks sp. Pl. II., fig. 1.

(*Steganoporella Jervoisii, Hincks, Ann. Nat. Hist.* 1880).

Zoarium encrusting. Zoœcia arranged in linear series, more or less quadrate, separated by raised margins; each zoœcium traversed by raised lines, of which two usually proceed from each side inwards, the lower inclined obliquely upwards, the upper downwards, each pair meeting about the central line, the points of junction being united by a vertical raised line; mouth very lofty, narrow, hollowed below, on each side a stout mamilliform process directed straight forwards.

Sorrento, Rev. Dr. Porter.

Micropora coriacea, var. angusta.

Micropora coriacea is a common species. As found in Australia it differs little from the European form, except in the general absence of the clavate elevations of the margins near the mouth, which, however, are occasionally seen. One variety seems worthy of being distinguished. In it the zoœcia are very long and narrow, the margins sharply raised and finely crenulated, the pouting lower lip marked in the same way, the front of the zoœcium punctate or finely perforated, but without any large lateral apertures. The oœcium does not present the usual knob-like elevation, and the avicularium has the mandible directed obliquely downwards. The whole zoarium is silvery, and frequently only loosely adnate.

Family CRIBRILINIDÆ.

Cribrilina monoceros, Busk, sp.

This is a common and somewhat variable species, and it seems to me that two distinct forms have been confused together. The true *C. monoceros* is that described and figured by Busk, and also in the Zoology of Victoria. The zoœcia are large, with large foramina, the margins of which are thickened. The mouth is large, and the lower lip raised into a central, pointed process. In some specimens there are no oral spines, while in others there is a single spine on one side, articulated close to the mouth, and really within the peristome when that is developed. There are occasionally two or three thin furcate spines on the upper margin of the mouth, and the lateral oral spine is sometimes similarly terminated. The avicularia are frequently wanting, or may be numerous and vary much. In some specimens they are scattered and small, close to the sides of the zoœcia, with sharp mandibles, while in others they are very large, with large, acute or spatulate mandibles, or occasionally small with blunt mandibles. They are also found of small size, sessile on eminences round the mouth. A small avicularium is sometimes found surmounting the mucronate elevation of the lower lip.

Cribrilina acanthoceros, n. sp. Plate II., fig. 4.

Zoarium adherent. Zoœcia with large foramina; mouth large, lower lip straight, with no mucro; a large spine, very long, and with sharp secondary spines or prickles directed forwards, articulated immediately below the lip and to one side; frequently a large avicularium, with triangular mandible at each side of the mouth towards the angle. Oœcia sub-immersed, surface with a thickened band, above which it is marked with cribriform depressions similar in form to the foramina of the zoœcia.

Port Phillip Heads; Portland, Mr. Maplestone.

This form differs from *C. monoceros,* chiefly in the following points:—The lower lip is always straight, and never developed into a mucro; the foramina are smaller, the oœcium is somewhat different in its appearance, and especially in the situation of the oral spine. In *C. monoceros* it is always situated at one side of the mouth, close to the margin, above the angle, and is enclosed within the peristome when one is developed. In *C. acanthoceros*, the spine, besides being very long, and furnished with the peculiar armature, is situated *below* the lower lip, and if a peristome should be developed (which I have never seen) would be outside it.

Family ESCHARIDÆ.

Porella formosa, n. sp. Plate II., fig. 6.

Zoarium encrusting or adnate. Zoœcia pyriform or elongated, separated by distinct raised margins; surface with a row of large areolæ around the margin; primary mouth slightly hollowed below; secondary enclosing inferiorily an avicularium, with a nearly semicircular mandible resting on a pouch-like elevation of the zoœcium; no internal denticle; a minute articular process on each side of the mouth for the attachment of the operculum. Oœcia large, galeate, prominent, margined by a thickened rim, and closely punctate.

Queenscliff.

Allied to *P. concinna*, but differing in the absence of an internal denticle and in the presence of a small articular process on each side of the mouth for the attachment of the operculum. This structure is not visible unless where the operculum has been detached or removed.

Schizoporella Woosteri, n. sp. Plate II., fig. 5.

Zoœcia broad, subquadrate, separated by distinct raised margins, surface granulated; mouth suborbicular, with a wide, rounded sinus below. An avicularium, with semicircular mandible on each side of the mouth at the upper angles of the zoœcia.

Queenscliff, Mr. Wooster.

Smittia calceolus, n. sp. Plate II., fig. 3.

Zoarium encrusting or adnate. Zoœcia much elongated, narrow, separated by narrow (sometimes indistinct) raised lines; surface rough or granular, a row of deep, rounded areolations along the margins; mouth broadly triangular, the peristome much elevated and produced into a point on each side, leaving a narrow, spout-like channel below; a broad, hammer-shaped denticle internally; immediately below the mouth an avicularium with a long, narrow mandible directed straight downwards. Oœcia partly immersed in the cell above, elongated and rounded above, depressed across the middle portion, thickly punctate.

Port Phillip Heads, found by Mr. Wilson and myself.

In the structure of the zoœcium this species precisely agrees with *S. reticulata*, but the oœcium is totally different. Instead of being rounded and projecting, it is elongated upwards, partly immersed and depressed across the centre, giving it a very peculiar appearance, somewhat like that of the flower of the well-known calceolaria. The difference in the oœcium is too great to admit of its being ranked merely as a variety of *S. reticulata*.

Family DISCOPORELLIDÆ.

Lichenopora bullata, n. sp. Plate III., fig. 2.

Zoarium encrusting, irregular; at intervals a minutely-punctate or perforated thin calcareous membrane, raised in inflated eminences, covering a considerable number of cells. Zoœcia irregular in shape and size; prismatic, with rounded angles; wall sthick, with numerous internal, minute, sharp spines. The zoœcia at the edges of the bullate elevations, with an elongated peristome on one side, spout-like or divided, directed towards the elevation; the zoœcia underneath the inflations, with their orifices, closed by a minutely granular membrane.

Port Phillip Heads, Mr. J. B. Wilson.

This is a most interesting form. The inflations are pretty regular, large, raised high above the zoœcia, and are evidently oœcia. At their margins some of the zoœcia are elongated, and pierce the edges. In these the side of the mouth is elongated in the direction of the centre of the inflation, the peristome being spout-like, sometimes dimidiate or with small lateral processes. The peristome of the other zoœcia is occasionally irregularly produced. The zoœcia under the inflations have their orifices closed by a minutely granular membrane.

As the generic name *Lichenopora* was proposed prior to that of *Discoporella*, it ought to be retained.

Lichenopora magnifica, n. sp. Plate III., fig. 3.

Zoarium encrusting, thick, raised into irregular mounds. Zoœcia frequently closed by a membrane a short way down, either entire or with a circular aperture in the centre; orifice very irregular in size, usually oval, with the peristome produced on one side into a thick, spout-like, nearly erect projection, or sometimes divided as in *L. pristis.* The zoœcia in many parts arranged on slight elevations as radiating ridges from a depressed central portion. In the lower and intervening zoœcia the peristome slightly developed, although often divided into two or three narrow processes; those on the ridges with the spout-like peristome large, entire or with small secondary processes on the sides, always pointing towards the central depression.

Port Phillip Heads, Mr. J. B. Wilson.

The specimen of this splendid species which I have examined spreads as an encrusting layer over a calcareous mass composed of cellepores and other polyzoa, and covers an extent of upwards of six inches. The whole is covered with large, irregular elevations, which are again nodulated. These large elevations are in part caused by the elevation of the calcareous zoophytal mass on which it grows, but several of the nodules having a diameter of a quarter of an inch or more, are entirely of this species, and in parts the continuous layer is of an equal thickness. As in other species, the zoarium extends by a basis, or lamina, in which the cells are developed. The individual zoœcia are more allied to those of *Lichenopora (Discoporella) pristis* than to those of any other species. All over the surface are slight elevations, composed of radiating, raised series, spreading from a central elongated or rounded level part. The zoœcia in the lower parts, between the rays and generally over the zoarium, either have the peristome not produced, or but slightly and divided into two or three sharp processes. Those on the ridges have it produced on one side into a stout, spout-like process directed towards the centre of the elevation. At first sight the numerous circular or oval elevations with radiating lines look as if the whole zoarium were formed by the coalescence of numerous small colonies, but it is not so, the margin being continuous.

Family Discoporellidæ.

Flosculipora, n. genus.

Zoarium small, pedunculate; the peduncle consisting of smooth tubes or ridges, with intervening cancelli towards the upper part. Zoœcia opening on an expanded summit; peristome produced, dimidiate or lacerated, with numerous intervening cancelli.

F. pygmæa, n. sp. Plate III., fig. 1.

This exquisite little species forms single tufts about 1-12th of an inch high, like miniature bouquets, growing on the cells of catenicellæ. The stem is composed of highly polished tubes, close together below, but distinct, and separated by rows of cancelli above. The zoœcia are, on the edges of the capitulum, arranged in converging rows separated by cancelli; the peristome is produced, and usually dimidiate, or extended only on one side; towards the centre of the head the peristome is wanting or represented by a small spinous process, and the cancelli are only distinguished by their smaller size.

Port Phillip Heads, Mr. J. B. Wilson.

EXPLANATION OF FIGURES.

Plate I.

Fig. 1. *Catenicella gemella.*
Fig. 2. *Claviporella pulchra.*
Fig. 3. *C. imperforata*, showing two sorts of oœcia.
Fig. 4. *C. aurita*, specimen with only single central foramen.
Fig. 5. *C. aurita*, showing enormously developed lateral processes.

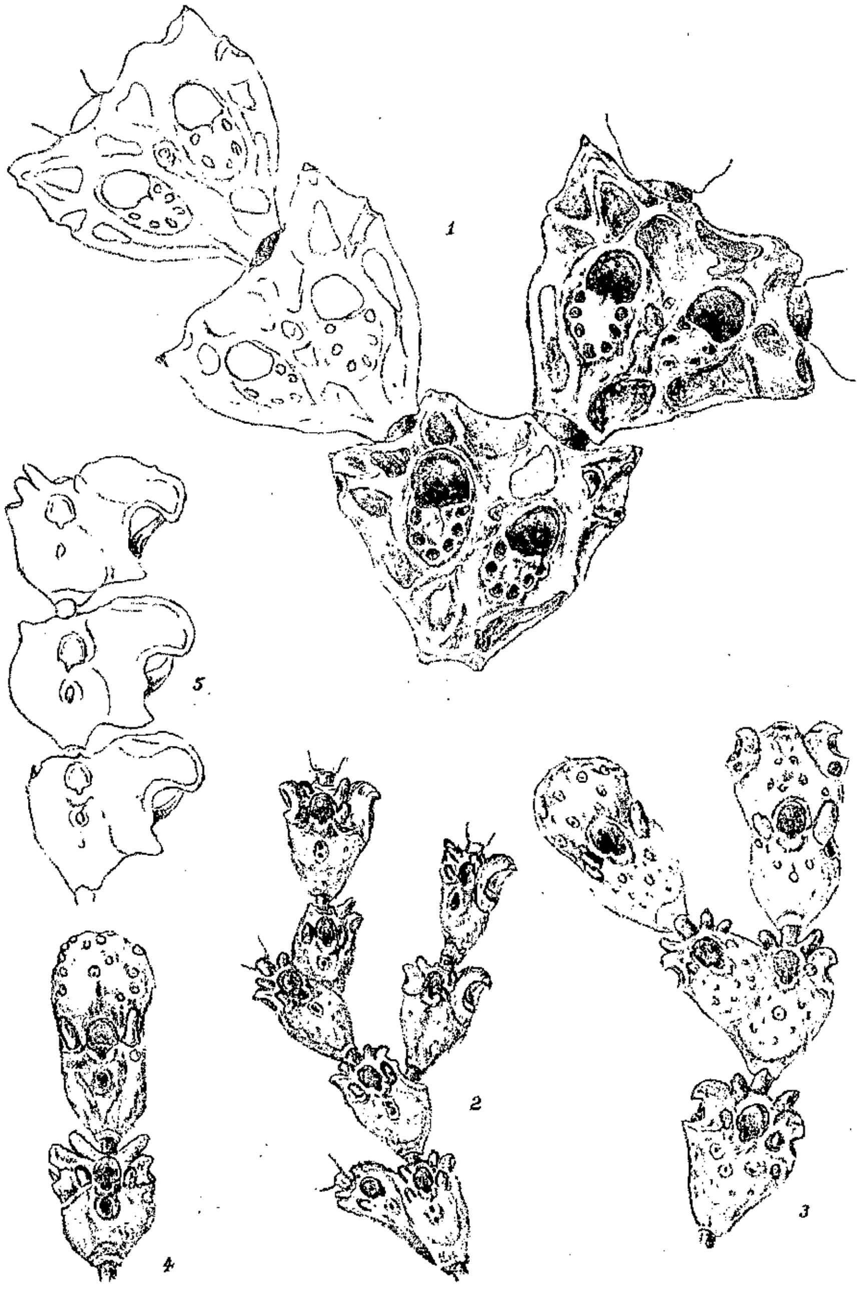
Plate II.

Fig. 1. *Thairopora Jervoisii.*
Fig. 2. *Amphiblestrum bursarium.*
Fig. 3. *Smittia calceolus.*
Fig. 4. *Cribrilina acanthoceros.*
Fig. 5. *Schizoporella Woosteri.*
Fig. 6. *Porella formosa.*

Plate III.

Fig. 1. *Flosculipora pygmæa.*
Fig. 2. *Lichenopora bullata*, natural size. Fig. 2a, portion of same, showing a broken oœcium, magnified. Fig. 2b and 2c, other zoœcia from the same.
Fig. 3. *Lichenopora magnifica*, small portion natural size. Fig. 3a, part of same magnified, showing portions of two radiating ridges and intervening surface.

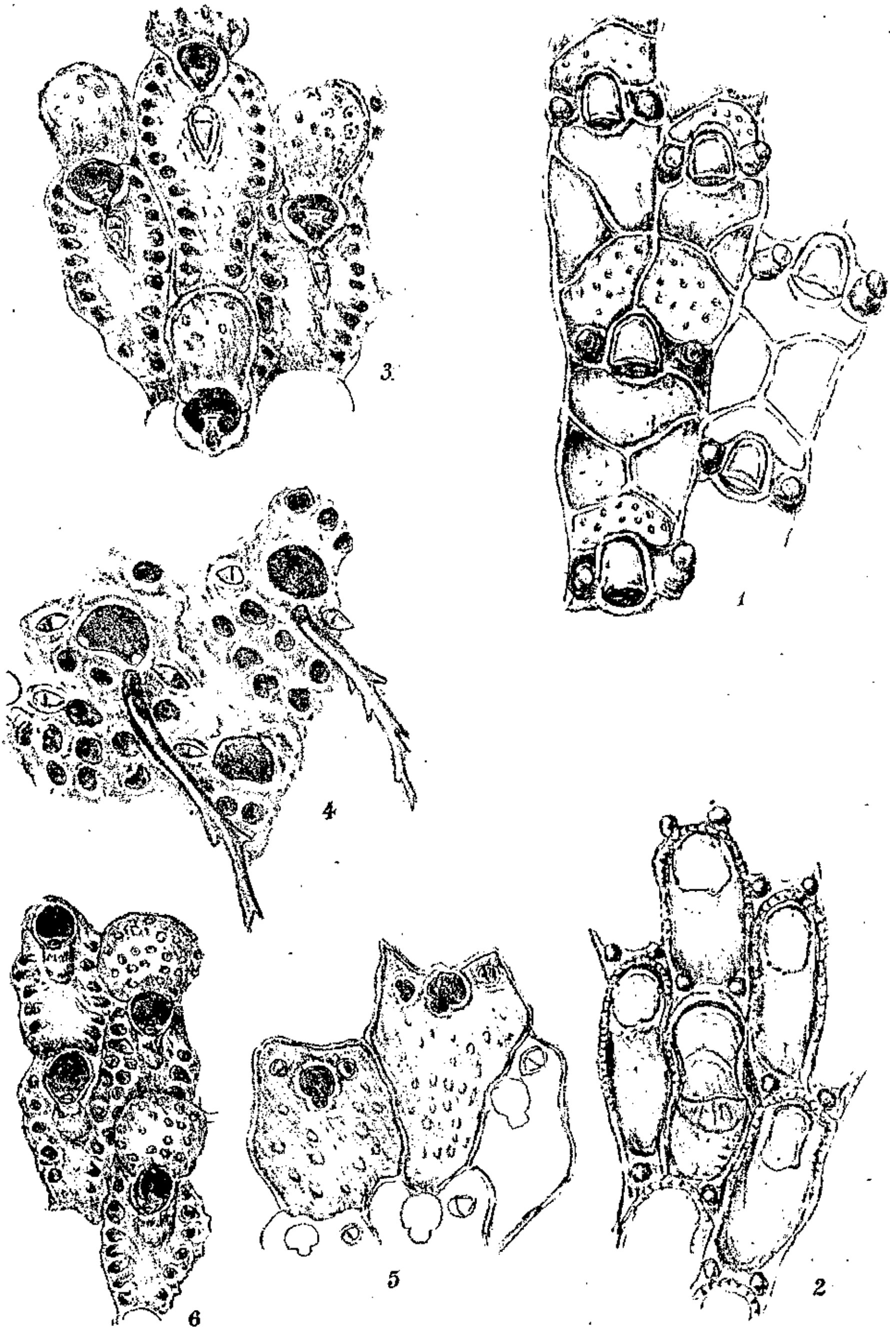
Plate I



P.H.Mc G. del & Lith.

C. Troedel & Co. imp.

Plate II



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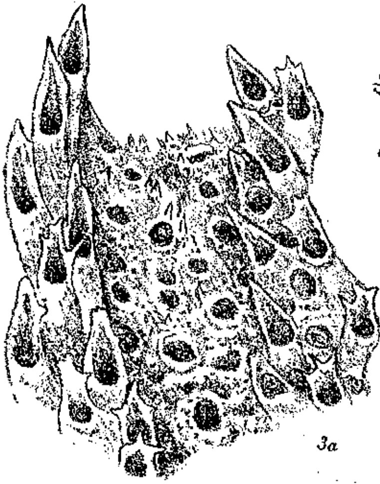
P. H. M^c G. del & Lith

C. Troedel & C^o imp.

Plate III.



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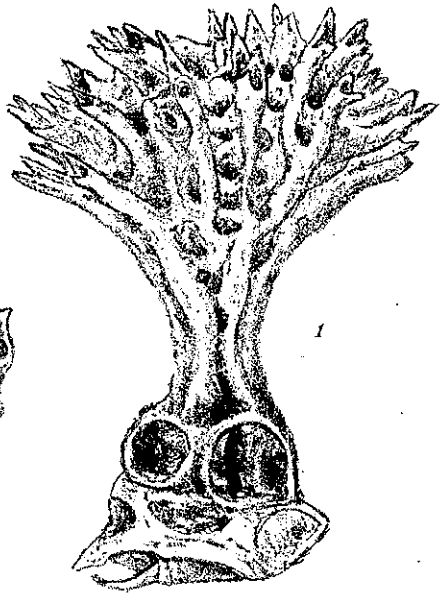

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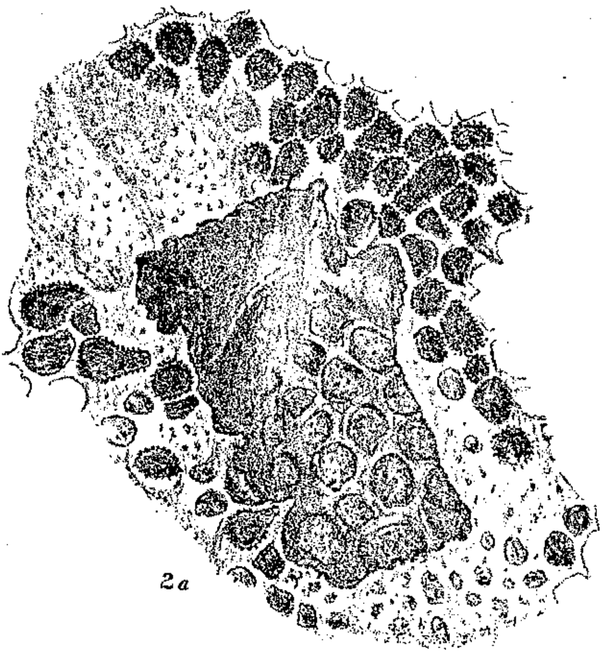
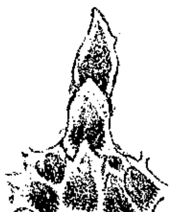


2a



2b.

2c

2

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P.H. McG. del & lith. G. Trendel & Co imp.

ART. IX.—*The Genera of the Plumulariidæ, with Observations on Various Australian Hydroids.*

BY W. M. BALE, F.R.M.S., HON. SEC. MICROSCOPICAL SOCIETY OF VICTORIA.

[Read 12th August, 1886.]

I.—INTRODUCTION.

THE principal objects of the present paper are, in the first place, to present a general summary of the classification of the Plumulariidæ, with suggestions for two or three modifications of the genera; and, secondly, to offer some further observations on a few of the Australian Hydroida, which have been previously described by myself or others. Professor Allman's Report on the "Challenger" Plumulariidæ, which contains descriptions of several Australian species, was issued after the "Catalogue of the Australian Hydroid Zoophytes" was in the printer's hands, and although it was not till six months later that I had the last opportunity of correcting and adding to the text of the "Catalogue," I was not then aware of Professor Allman's work having appeared, and was, consequently, unable to adopt any of the new genera proposed therein, or otherwise to avail myself of its valuable assistance. Among the species described as new in the Report, one or two appear to me identical with some of Mr. Busk's, and the new genus and species *Halicornopsis avicularis*, described by me in the Journal of the Microscopical Society of Victoria for 1882, is re-described under the name of *Azygoplon rostratum*. These species, with others which are dealt with in the Report, will be more particularly treated of further on, after the general remarks on the Plumulariidæ.

In addition to Professor Allman's work, there have appeared, since the completion of the "Catalogue," a list of localities for Australian Hydroids by Dr. Kirchenpauer, a paper by the same author on Northern Genera and Species of Hydroida, which includes also descriptions of several new Australian species, and Dr. Lendenfeld's series of papers on the Australian Hydromedusæ, in which are included descriptions of a number of new and interesting species, and several new genera, with a list of all the species previously described, and much valuable information respecting the histology of those which the author has studied. I propose to make some further remarks regarding these works before the conclusion of the present paper.

II.—Classification of the Plumulariidæ.

In the "Challenger" Report Professor Allman divides the Plumulariidæ into two principal sections or sub-families, the *Eleutheroplea* and the *Statoplea*. The first of these corresponds to the genera Plumularia and Antennularia of Mr. Hincks and later authors, with such recent genera as are nearly allied to them; the second consists of the Aglaophenia of Hincks and Kirchenpauer, with some other genera possessing the same general type of trophosome. In the Eleutheroplea the lateral sarcothecæ are almost invariably movable, and none of those which surround the hydrotheca are actually attached to it; in the Statoplea, on the contrary, the lateral, and generally the anterior sarcothecæ, are in contact with the hydrotheca for at least a part of their length, and none of them are movable. The hydrothecæ in the Eleutheroplea are usually more or less cup-shaped, with the margin plain, or occasionally sinuated, but not toothed, and are in most cases set at some distance apart, so that the hydrophyton has a graceful, slender aspect; while those of the Statoplea are generally closely set on the hydrocladia (or hydrotheca-bearing ramules), and are furnished with teeth or lobes on the margin. But none of these distinctions can be relied upon invariably, as several Statopleans have distant hydrothecæ with smooth margins, while some Eleutheropleans have closely-ranked hydrothecæ with sinuated margins, and Professor Allman says that at least one species has the margin distinctly toothed. There appears to be, in fact, no single characteristic to which we can point as invariable. I thought to have found such a distinction in the fact that the supracalycine sarcothecæ of Statopleans when present are wholly or partially attached to the hydrotheca, while in the Eleutheroplea they are not so attached; but Halopteris is perhaps an exception to the latter rule, and in some Plumularians the supracalycine sarcothecæ are entirely wanting. But notwithstanding the difficulty of framing definitions which would be universally applicable, it is in most instances easy to refer a species to its proper sub-family by its general facies, and by the predominance of the characters of one group over those of the other.

The prevalence in the old genus Aglaophenia of special ramuli, armed with nematophores, and serving to protect the gonangia, has long been familiar, and of late years two genera of Hydroids have been made known which combine such gonangial structures with the trophosome of a typical Plumularia. Professor Allman accordingly divides each of the sub-families Eleutheroplea and Statoplea into two minor groups—the Phylactocarpa, which have the gonangia protected by some form of "phylactocarp," or special ramulus armed with nematophores; and the Gymnocarpa, which are destitute of any such structures. The phylactocarpal ramuli of Aglaophenia and its allies are the "nematocladia" of Kirchenpauer.

Note on the Intrathecal Ridge.

With regard to the structure of the hydrotheca in the Plumulariidæ, the "Challenger" Report says :—"In almost every case there is present in the hydrotheca of the Statoplea a slightly projecting chitinous ridge, which runs on the inner surface of the walls transversely from behind forwards, but with a more or less oblique direction, and which more or less completely encircles the cavity of the hydrotheca, thus forming an imperfect septum, which divides the hydrotheca into a proximal and a distal portion. This is the intrathecal ridge, which, as just said, is never present in the Eleutheroplea. In some species of Statoplea, what has the appearance of a similar ridge running from before backwards may be seen in the anterior portion of the hydrotheca. This, however, is only the optical expression of a fold in the walls of the hydrotheca." So far as the Australian Plumulariidæ are concerned, however, the condition is just the opposite of that stated in the foregoing extract, and the true intrathecal ridge, or partial septum, is that which runs from before backwards, while the posterior one is generally a mere fold in the walls of the hydrotheca. In the half-dozen species of which *Halicornaria superba* is the type,* and also in *Aglaophenia Huxleyi* and *A. phœnicea* (both of

* In *H. speciosa*, a species of this group figured in the Report on the Gulf Stream Hydroids, the anterior ridge is described by Professor Allman as the "intrathecal ridge."

which are included in the "Challenger" Report), the anterior intrathecal ridge is very conspicuous, being a true partition extending fully half way through the hydrotheca; and if we look into the aperture of the latter at a proper angle we see that the ridge is, in most cases, even more prominent at the centre than where it joins the walls of the hydrotheca, and that it is often thickened at the edge and crenate. In no Australian species have I seen the posterior ridge so prominent, the only one in which I have found it well developed being *Aglaophenia divaricata,* particularly the variety which I formerly described as *A. M'Coyi;* and none of the ten species of Halicornaria included in the "Catalogue" show any trace of it. The posterior ridge, however, though stated to be always wanting in the Eleutheroplea, is really present in a rudimentary form in the stout variety of *Plumularia obliqua* and in *P. filicaulis,* and is well developed in *P. Australis,* and still more in *P. spinulosa.* The anterior ridge is large in *P. producta,* extending half through the hydrotheca. The use of the intrathecal ridge is evidently to form a protective shield, behind which the hydranth can retire; and if we consider its structure and origin it will be sufficiently obvious that whether it springs from the back or from the front of the hydrotheca its nature is essentially the same, and that it originates from a fold or constriction of the hydrothecal wall, which is more or less bent upon itself either towards or away from the hydrocladium, or in both directions alternately. If we take a tubular sac of any flexible substance, and bend it slightly upon itself near the base, we shall make a fold or crease, deepest on the side towards which we bend the sac, and partially encircling it. This represents the slight fold which crosses so many species of Aglaophenia near the base, constituting a rudimentary posterior ridge. If we now take the same sac, and bend the other extremity in the opposite direction, we shall have a fold on the opposite side, and nearer the mouth. This is found in many species, and varies from a slight narrowing below the aperture to a deep inflection, according to the degree to which the distal part is recurved. This double curving is well shown in *Aglaophenia longicornis* and in the *Cladocarpus ventricosus* of Allman's Gulf Stream Hydroids. It is but a step further to those forms in which the recurved portion is intimately united to the body of the sac, so that the double plate thus formed becomes an internal partition, as seen in *Aglaophenia*

Huxleyi and *A. phœnicea*, and, in a still more advanced stage, in the before-mentioned section of Halicornaria.

STRUCTURE OF THE STEM AND BRANCHES.

In examining the structure of the hydrocaulus, particularly among the Statoplea, I find that there are two distinct modes of branching, one of which is mainly characteristic of the monosiphonic species, while the other is only possible where there is a compound stem. In the former case the stem and branches are simple jointed tubes, which, when the hydrophyton is large, are of considerable thickness, and the branches spring from the ordinary internodes, behind or between the hydrocladia, or occasionally, in some species, replacing them. In most polysiphonic species, on the other hand, the primary jointed stem is slender (the requisite strength being given by the compound stem, which is only developed as the zoophyte increases in size), and the branches spring, not from the jointed stem, but from the supplementary tubes which grow up in contact with it. For example, in *Aglaophenia longicornis* we find at the back of the original slender jointed stem a stouter secondary tube, and from this spring at regular intervals the alternate pinnately-arranged branches. In such species as this it is evident that the fascicled structure must be developed before the branches can be produced, and is therefore essential to the normal growth of the hydrophyton, but there are species which, in the thick stem and the mode of branching, agree precisely with the typical monosiphonic forms, but which, nevertheless, have the lower part of the stem and branches fascicled; in such cases the adventitious tubes might be absent without affecting the general habit.

As regards the origin of the compound stem, it is obvious that the supplemental tubes are hydrorhizal elements. Monosiphonic species sometimes occur, with a few irregular tubes, which, springing from the hydrorhiza, have attached themselves to the basal part of the stem instead of to a foreign body. In *Halicornopsis avicularis* (as in many Sertularians) the additional tubes are regularly present, and are so numerous as to thicken the stem considerably, while in the typical polysiphonic species they are, as shown above, of still more importance. Keeping in mind the hydrorhizal origin of the polysiphonic stem, we see that in *Aglaophenia longicornis*, for example, every one of the main pinnæ is equivalent to a separate shoot of such species as *A. parvula*, a fact which is further illustrated by the presence, near the base of the stem in the latter species (and, indeed, in many others), of a long oblique joint similar to that which exists near the base of each pinna in *A. longicornis.* Such a joint is seen in young specimens of *A. divaricata*, and when the supplementary tubes grow up, and branches are produced, each branch has a similar joint. I have not hitherto met with any species with branches springing both from the jointed stem and the added tubes.

ELEUTHEROPLEA.

PLUMULARIA, *Lamk.*, modified.

Hydrocladia pinnately arranged; sarcothecæ not attached to the hydrotheca.

Gonangia not provided with phylactocarps.

Lamarck's genus Plumularia was originally formed to include the whole of the pinnate Plumularians, and was synonymous with the Aglaophenia of Lamouroux. The latter author, however, suggested a subdivision of the genus, which was adopted by M'Crady and later authors, and in which the name Plumularia was assigned to the Eleutheroplean species, and Aglaophenia to the Statoplean. According to Professor Allman's views the genus should be still further limited, so as to include only those species with all the sarcothecæ movable; and in the "Challenger" Report he proposes a new genus—Heteroplon—for a species which has the anterior sarcotheca in the form of a stout fixed spine, curved towards the hydrotheca. This condition of the sarcotheca, however, is common to several of our species, while in others it differs from that of a typical Plumularia only in its stouter base and consequent wider area of attachment, which renders it rigid. Every possible degree of variation exists between the long, slender sarcotheca, which is swayed by every motion of the fluid surrounding it, and the short fixed spine of *Heteroplon pluma;* it follows, therefore, that there is no definite line of demarcation between Heteroplon and Plumularia. Of the species described in the "Catalogue," *P. Ramsayi, P. cornuta, P. setaceoides, P. effusa, P. obliqua, P. spinulosa, P. hyalina, P. pulchella,* and probably *P. badia,* have the anterior sarcothecæ perfectly movable, and would come under the genus as limited by Professor Allman. *P. obliqua* and the three following species agree in having only a single hydrotheca on each pinna. In *P. delicatula* the anterior sarcothecæ are small, and, though agreeing in all essentials with those of the abovenamed species, seem more rigid, always retaining the same position, at least when dry. In *P. campanula* the supracalycine, as well as the anterior sarcothecæ, are short and stout, and so firmly attached as to prevent any variation of their position. If forcibly pushed aside they instantly assume their normal position on removing the pressure. Notwithstanding the fixed nematophores, this species is described by Professor Allman in the Report as a Plumularia, under the name of *P. laxa*. The other species described in the "Catalogue" which have the anterior sarcotheca immovable, and curved towards the hydrotheca, are *P. Buskii*, *P. aglaophenoides*, *P. Goldsteini*, *P. filicaulis*, *P. compressa*, *P. Australis*, and probably *P. obconica*. *P. compressa* and *P. Australis* agree with *P. obliqua* and its immediate allies in having only one hydrotheca on each pinna, but differ in the stout fixed anterior sarcothecæ, which look like projecting portions of the hydrocaulus. In several of the species the sarcotheca is so strongly curved towards the calycle as to seem almost appressed to it.

It will be seen, therefore, that among the Australian Eleutheroplea the fixed condition of the anterior sarcothecæ is by no means rare, as, according to Professor Allman, it is in the sub-family generally, and that, in fact, it obtains in at least half our species. As it is not constantly associated with any peculiar form of the sarcotheca, but depends merely on its relative size at the point of attachment and the firmness of the perisarc, and does not imply any important structural distinction, it seems best to include all the species under the genus Plumularia—in other words, to continue to take that genus in the sense in which it is used by Hincks, Kirchenpauer, and most other recent writers on the Plumulariidæ. I would further suggest that the other Eleutheroplean genera should be made sufficiently comprehensive to include species which differ from each other only in the fixed or movable condition of the anterior sarcothecæ.

HALOPTERIS, *Allman.*

Hydrocladia pinnately arranged; mesial sarcothecæ not adnate to the hydrothecæ; laterals fixed, adnate.

Gonangia unknown.

H. carinata, the only species, agrees with the typical Eleutheroplea in the form and position of the calycles, and the anterior sarcothecæ, though fixed, are attached by a slender base. The supracalycine sarcothecæ are described as adnate to the side of the hydrotheca, which character is unknown elsewhere in the sub-family. In Professor Allman's figures, however, the cup of the sarcotheca is shown raised above the margin of the hydrotheca, and the long tubular adnate portion seems rather to resemble the peduncles which, in several species of Plumularia, support the sarcothecæ, than an intimate part of the latter organs.

ACANTHELLA, *Allman.*

Hydrocladia pinnately arranged, those near the tips of the branches replaced by spines; sarcothecæ not attached to the hydrotheca.

Gonosome unknown.

The genus Acanthella is formed for the single species, *Plumularia effusa* (Busk), and differs from Plumularia only in having spines armed with nematophores in place of the hydrothecal ramules towards the extremities of the branches.

ANTENNELLA, *Allman.*

Hydrocladia simple, springing directly from the hydrorhiza; sarcothecæ not attached to the calycle.

Gonangia not provided with phylactocarps.

This genus is distinguished from Plumularia by the absence of a stem. In several Plumularians, however, simple ramuli like those of Antennella have been found growing from the same hydrorhiza with ordinary pinnate shoots. This has been observed by Busk in *Plumularia campanula,* by Kirchenpauer in *P. filicaulis,* and by myself in *Halicornaria humilis,* and it is quite possible that all the species of Antennella may be similar stemless forms of ordinary ramulose species.

SCHIZOTRICHA, *Allman.*

Hydrocladia pinnately arranged, bifurcating once or more; sarcothecæ not attached to the hydrotheca.

Gonangia not provided with phylactocarps.

The distinguishing feature in this genus is the bifurcation of the pinnæ. In both known species there is seated in each bifurcation a hydrotheca without nematophores. One of them is further remarkable for having two sarcothecæ side by side in place of the usual anterior one.

POLYPLUMARIA, *Sars*, modified.

Hydrocladia pinnately arranged, with an accessory hydrothecal ramulus springing from the proximal internode of each; sarcothecæ not attached to the hydrothecæ.

Gonangia not provided with phylactocarps.

The genus Polyplumaria of Sars was characterised mainly by its doubly pinnate ramification, while Diplopteron (Allman) was distinguished by the same feature, and also by the possession of two pairs of lateral sarcothecæ above the hydrotheca. In the "Challenger" Report the species are united under Polyplumaria, and the generic characters modified, making the essential feature the possession of an accessory ramulus bearing hydrothecæ, and springing from the proximal internode of each pinna. According to Sars' figures, his *Plumularia gracillima* has the same peculiarity, and our *P. cornuta* also has the secondary ramulus, though in an aborted or rudimentary form.

MONOSTÆCHAS, *Allman*.

Hydrocladia arranged uniserially; sarcothecæ not attached to the hydrotheca.

Gonangia not provided with phylactocarps.

In the only known species of this genus the hydrocladia are arranged in a single series along the distal side of the branches, somewhat as in the Gymnoblastic genus Pennaria. The minute structure is like that of *Plumularia Catharina*.

ANTENNULARIA, *Lamarck*.

(*Nemertesia*, Lamouroux.)

Hydrocladia disposed along three or more sides of the stem; sarcothecæ not attached to the hydrothecæ.

Gonangia not provided with phylactocarps.

The hydrocladia of Antennularia have been usually described as verticillate. The above definition will include all the species now known, among which are the *Heteropyxis* *norvegica* of Sars, in which the hydrocladia are in threes, with a sub-spiral arrangement; the *Nemertesia decussata* of Kirchenpauer, which has the hydrocladia in pairs, each pair being in a plane at right angles to that of the pairs next above and below, so as to form four series on the stem; and the *Antennopsis hippuris* of Allman, in which they are without definite order. Professor Allman now considers Antennopsis not distinct from Antennularia.

SCIURELLA, *Allman.*

Hydrocladia disposed round the stem; sarcothecæ not attached to the hydrotheca.

Gonangia with horn-like processes, and a ramified blastostyle.

The only species known has the hydrocladia arranged as in *Antennularia decussata,* and differs from Antennularia only in the gonosome.

The genera already passed in review belong, so far as is known, to the Gymnocarpa; the two remaining genera, Hippurella and Callicarpa, constitute the Phylactocarpal section of the Eleutheroplea. Each of these genera is at present represented by a single species only; both are from the North American coast, and both are very similar in the minute structure of the trophosome.*

HIPPURELLA, *Allman.*

Trophosome as in Plumularia.

Gonangia protected by phylactocarps, which consist of nematocladia arranged verticillately at the tips of the ordinary branches.

Professor Allman described this genus in the Report on the Gulf Stream Hydroids, but supposed the verticillate branchlets to be hydrocladia. Mr. Fewkes, on further examination, found that they were provided with nematophores instead of hydrothecæ, constituting a phylactocarpal gonosome. In the only known species there are six ramuli in each verticil.

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* In the "Catalogue" I have inadvertently stated that these genera have a similar trophosome to that of Aglaophenia.

CALLICARPA, *Fewkes.*

Trophosome as in Plumularia.

Gonangia protected by phylactocarps, which consist of nematocladia, arranged verticillately, and occupying a short distinct branch.

The principal difference between Callicarpa and Hippurella is in the position of the gonosomes, which in the former genus form distinct branches, instead of being the distal portions of the ordinary ones. In the single species which is known the phylactocarps are produced in verticils of three, and each one is twice bifurcated, so as to form four spine-like ramuli, each whorl thus consisting ultimately of twelve ramuli, which curve upwards, the whole gonosome resembling a spike of barley. The close alliance with the preceding genus is obvious, and, as Mr. Fewkes remarks, "it is, morphologically speaking, as if the proximal part of the branch which bears pinnæ in Hippurella was reduced to a peduncle, and the distal end, with its verticillate ribs, became the gonosome."

GATTYA, *Allman.*

Hydrocladia springing directly from the hydrorhiza, or from other hydrocladia, borne on jointed peduncles; hydrothecæ with a toothed margin; lateral sarcothecæ movable.

This genus is peculiar in its habit, the hydrocladia growing directly from the hydrorhiza, or springing irregularly from each other; but in either case the basal part is composed of a number of short joints without appendages, forming a sort of peduncle. The anterior sarcotheca is of the fixed type found in several of our Plumulariæ (which would be included in the genus Heteroplon of Allman), and the toothed calycle is, according to Professor Allman, unknown elsewhere among the Eleutheroplea.

STATOPLEA.

The genus Aglaophenia, as understood by Hincks and Kirchenpauer, included the whole of the Statoplean Plumulariidæ, both Phylactocarpal and Gymnocarpal. Professor Allman separated the species with unprotected gonangia, under the name of Halicornaria, but at first associated with them a species (*H. saccaria*) which has the gonangial ramules slightly modified. I suggested in the

"Catalogue" that such species should rather be associated with those in which the gonangial pinnæ are still further altered, and that only the species with unprotected gonosomes should be included under Halicornaria. Professor Allman independently came to the same conclusion, and, in the "Challenger" Report, proposed the genus Lytocarpus (an adaptation of Kirchenpauer's sub-genus Lytocarpia) for the species which have the gonangia borne on modified pinnæ; but also included in it a section of the corbula-bearing species. This appears to me by no means the most natural arrangement, as will be apparent if we divide the species of Aglaophenia and Lytocarpus admitted by Professor Allman into three groups, as follows:—

1. A corbula present, the ribs of which form leaflets, and do not bear hydrothecæ (Aglaophenia, Allman).
2. A corbula present, the ribs of which bear a single hydrotheca near the base, and do not form leaflets (*Lytocarpus*, Allman, part).
3. No corbula, gonangia borne on scattered modified pinnæ (*Lytocarpus*, Allman, part).

In view of the fact that the first and second of these sections agree in the presence of a corbula—which, moreover, is in each case formed from the same structural elements, only somewhat differently modified—while in the third group the corbula is entirely absent, it seems evident that the first two groups are much more nearly allied to each other than either of them is to the third, and, consequently, if there is to be any generic separation, this group must stand alone. I propose, therefore, to modify the generic description of Lytocarpus so as to make it include this section only—that is to say, all the species in which the gonangia are borne on pinnæ, the distal portions of which are modified by the suppression of the hydrothecæ, so as to form nematocladia. It is to be observed that it is not the scattered position of these nematocladia which so sharply distinguishes this section from all the true corbula-bearing species (in fact, the *Lytocarpus racemiferus* of Allman has the nematocladia brought together in a special part of the branch, so as to form what may be called a "pseudo-corbula"); but the fact that the true corbula is composed of nematocladia which are not modified pinnæ, but secondary structures springing from the pinnæ, and not represented at all in the species which I would assign to Lytocarpus.

Coming now to the question as to whether the first two of the foregoing groups should be re-united under Aglaophenia, or whether the second should be considered a distinct genus, I am strongly inclined to adopt the former course. The distinctions between these two groups, as laid down by Professor Allman, are simply that in the first the corbula-ribs form leaflets, and do not bear hydrothecæ, while in the second they are rod-shaped or sabre-shaped, and have a hydrotheca near the base of each. If these differences were constant they might be deemed of generic importance; but in such species as *A. divaricata* (Busk) and *A. acanthocarpa* (Allman) the ribs are almost filiform, and certainly do not merit the name of leaflets so much as do those of *A. distans* (Allman), which, nevertheless, Professor Allman would now place under Lytocarpus, presumably on account of the ribs bearing hydrothecæ; while in *A. vitiana* (Kirchenpauer) we have a species in which the ribs of the corbula assume the form of broad leaflets, like those of *A. pluma* and its allies, except that they are only united to each other at intervals along the margins instead of continuously, and yet bearing each a hydrotheca, as in the species of the other section. Seeing, therefore, the impossibility of drawing any satisfactory line between them, I regard all the true corbula-bearing species as belonging to the genus Aglaophenia, the essential character of which will be the possession of a corbula, the ribs of which are secondary structures, springing from a modified pinna, and consisting of the modified mesial nematophores of the hydrothecæ near their base, which hydrothecæ may be either present or suppressed.

The *Lytocarpus secundus* of Allman is a very exceptional species, but if, as Professor Allman supposes, the single series of nematocladia borne by the gonangial pinna be homologous with the ribs of the corbula of Aglaophenia, it may be regarded as an aberrant form of that genus. This seems the more likely, from the fact that the spine-like nematocladia are only borne on alternate internodes, as if the whole of one series had been suppressed.

The homology of *Aglaophenia myriophyllum* seems to be in dispute, as Professor Allman says that its corbula consists of ribs formed exactly as in other species by the modification of the mesial nematophores of the hydrothecæ at their base; while Mr. Hincks states that these structures "do not *take the place* of the anterior sarcotheca, which is present, as usual, but spring from the stem supporting the calycle between the latter and the sarcotheca;" and he adds that "in some cases after reaching a certain height they give origin to a second calycle similarly placed;" and he consequently concludes that they are modified ramuli, in which case the species would come under the genus Lytocarpus, as herein restricted.

AGLAOPHENIA, *Lamouroux*, modified.

Hydrocladia pinnately arranged, mesial and lateral sarcothecæ attached to the hydrotheca for at least a part of their length.

Gonangia produced in a corbula, the rachis of which is a modified hydrocladium, and the ribs modified mesial sarcothecæ, often united to form a closed sac.

According to the above definition the genus will include all the true corbula-bearing species which Professor Allman ranks under Lytocarpus. I have taken for granted the correctness of Professor Allman's theory of the origin of the corbula. According to this view the hydrothecæ of the gonangial pinna become, in certain species, turned alternately to the right and the left, and raised above the pinna on peduncles, and it is the mesial sarcothecæ of these hydrothecæ which, becoming enormously enlarged and developing a number of secondary sarcothecæ, constitute the ribs of the corbula. Mr. Fewkes' objection that this view assumes the existence of two series of hydrothecæ side by side on the gonangial pinna is based on a misconception, as the pinna consists only of a single series of internodes with a hydrotheca on each, though the fact of the hydrothecæ being turned alternately to right and left gives them the appearance of being biserial. It is an easy transition to such species as *A. divaricata*, which have the hydrothecæ of the corbula entirely suppressed; and, whether the hydrothecæ be absent or not, the ribs may be represented by broad leaflets, and united to form a pod. Such species as *A. divaricata* have the secondary sarcothecæ of the narrow corbula-ribs in distinct pairs, and usually very much larger than those which border the broad leaflets of *A. parvula* and its allies.

Of the Australian species whose gonosomes are known, those which have an open corbula, with numerous narrow ribs, like those of *A. acanthocarpa* (*Allman*), are *A. divari-*

cata, A. plumosa, A. ramosa, and *A. formosa;* those which have a closed corbula are *A. parvula, A. pluma, A. MacGillivrayi, A. crucialis,* and *A. Lendenfeldi (A. Kirchenpauri, Lend.)*

LYTOCARPUS, *Allman*, modified.

Trophosome as in Aglaophenia.

Gonangia protected by nemotocladia, which consist of modified hydrocladia, and do not produce secondary ribs.

There are two Australian species described in the "Catalogue" which will have to be placed under this genus—namely, *A. urens* and *A. phœnicea.* In the former the scattered gonangial pinnæ bear several hydrothecæ below the gonangium, but above it are abbreviated and provided with nematophores only. *A. phœnicea* has every third pinna on each side of the fertile branches altered into a nematocladium, bearing only a single hydrotheca below the gonangium, and having the rest of its length recurved, and armed with two series of large nematophores. In *L. racemiferus* (Allman) the nematocladia are all brought together into a particular part of the branch, forming a pseudo-corbula. In this species each joint of the nematocladium bears three sarcothecæ, the mesials of the suppressed hydrothecæ being retained as well as the laterals.

There is a striking resemblance between the nematocladia of *L. phœniceus* and those of *A. divaricata.* In the "Catalogue" I have cited these species, along with *A. urèns, A. patula* (K.) and Pleurocarpa, as showing the stages in the transition between species with naked gonangia and those with a true corbula; but this seems to be an error, caused by superficial resemblances, since the nematocladia of *L. phœniceus* and its allies are altered pinnæ, while those of *A. divaricata* are modified mesial nematophores, and those of Pleurocarpa are, according to Allman, homologically distinct from either.

CLADOCARPUS, *Allman.*

Trophosome as in Aglaophenia.

Gonangia protected by phylactogonia (special protective branches which spring from the hydrocladia).

In all the known species of this genus the phylactogonia spring from the proximal internode of an ordinary hydrocladium, and are curved over the gonangium, which may be borne on the phylactogonium itself, or on the stem, or in both positions. They do not take the place of the mesial nematophore of the proximal hydrotheca, though in one or two cases these hydrothecæ are destitute of a mesial nematophore; but it is suggested that they may represent the nematophores of hydrothecæ which are suppressed. They are usually, but not always, branched and antler-like.

Several species of Cladocarpus are noticeable for being of a more slender and flexuous type than the Statoplea generally, and for having much elongated hydrothecæ, with even margins. In one or two species the anterior sarcotheca does not touch the hydrotheca.

AGLAOPHENOPSIS, *Fewkes.*

Trophosome as in Aglaophenia.

Gonangia protected by special ramuli, each of which is a modification of the mesial sarcotheca of the proximal hydrotheca on a pinna.

The characters relied on by Mr. Fewkes to distinguish this genus from Cladocarpus are the unbranched and jointed condition of the phylactocarp; but Professor Allman has described a species of Cladocarpus with jointed phylactogonia, and does not consider the branching essential. The phylactocarps of Aglaophenopsis, however, are modified from the mesial nematophores of the proximal hydrothecæ, while in Cladocarpus they are independent structures, and the genus, if retained, must rest on this distinction.

PLEUROCARPA, *Fewkes.*

Trophosome as in Aglaophenia.

Corbula formed from part of a branch, of which the other portion bears hydrocladia.

Mr. Fewkes regards the gonosome in this genus as undoubtedly formed from a branch, which seems proved by the presence of the ordinary pinnæ on the distal portion; he also considers it homologous with the corbula of Aglaophenia, but this view cannot be correct, as the corbula in that genus is formed from a pinna. The arched ribs forming the corbula are supposed by Professor Allman to represent the phylactogonia of Cladocarpus, the pinnæ which in that genus support them being here entirely suppressed. Mr. Fewkes, on the other hand, seems to regard them as altered pinnæ. If the latter supposition be correct, there is nothing to separate the genus from Lytocarpus, one species of which *(L. racemiferus)* has the nematocladia all together in one portion of the branch. The form of the tubular sarcothecæ on the ribs, however, approximates most nearly to that found in some species of Cladocarpus, and the fact that they are described as projecting at right angles on all sides of the ribs does not favour the theory that the latter are modified pinnæ, as when this is the case the sarcothecæ are arranged symmetrically in the same median or lateral positions which they would occupy if the hydrothecæ were present. A remarkable feature of *P. ramosa* is the presence on the most proximal part of the fertile branch, where no pinnæ are produced, of a series of hydrothecæ. Professor Allman suggests that they may be nematophores, which have been mistaken for hydrothecæ, and there is no doubt that the structure strikingly resembles in appearance the proximal part of the ordinary branches in such species as *Aglaophenia divaricata*, which are destitute of pinnæ, and bear a central series of large sarcothecæ. I know of no case among the Statoplea where hydrothecæ are regularly borne directly on a stem or branch, though I have met with an abnormal instance of such a case.

ACANTHOCLADIUM, *Allman*.

Hydrocladia replaced by spines at the tips of the branches; remainder of trophosome and gonosome as in Aglaophenia.

This genus is distinguished, like Acanthella among the Eleutheroplea, by having the pinnæ at and near the tips of the branches in the form of hollow spines, destitute of hydrothecæ. The ribs of the corbula in *A. Huxleyi* are not flattened, and each bears a hydrotheca.

PENTANDRA, *Von Lendenfeld*.

Hydrocladia pinnately arranged, a mesial and two pairs of lateral sarcothecæ adnate to each hydrotheca.

Gonosome a corbula, as in Aglaophenia.

Two species of this very distinct genus have been described by Dr. von Lendenfeld. The hydrothecæ resemble those of a typical Aglaophenia, with tubular mesial and lateral sarcothecæ in the usual positions, but possess, in addition, a second pair of laterals, which are adnate to the sides of the hydrotheca as far as the margin, above which, in both species, they rise to a considerable height, the free part about equalling the adnate. The mesial sarcothecæ are about as long as the hydrotheca, so that the added pair of laterals are much the longest of the five. Both species have a closed corbula, of the same type as that of *A. pluma*.

HALICORNARIA, *Busk*, modified.

(*Gymnangium*, Hincks.)

Trophosome as in Aglaophenia.

Gonangia not protected by phylactocarps.

This genus is now taken to include only those species which are destitute of any form of phylactocarp. It was first proposed by Busk for all the pinnate Gymnocarpal Plumularians, but modified by Allman, so as to exclude the Eleutheroplea. Hincks, however, had previously proposed the name Gymnangium for the group now included under Halicornaria, but though the former name had the priority, it has been universally passed over in favour of the latter. All the species of Halicornaria described in the "Catalogue" are destitute of folds in the hydrothecal internodes. None of them have any trace of the posterior intrathecal ridge, but in *H. superba* and its allies the anterior ridge is very conspicuous.

Professor Allman's *H. plumosa* should be re-named, as Dr. Armstrong has described a species under the same name.

The *Halicornaria ramulifera* of the "Porcupine" expedition appears to me so distinct by reason of the separation of the mesial nematophores from their hydrothecæ, and the interposition of the accessory ramuli, that a distinct genus ought to be established for its reception. Each internode of the hydrocladia bears one of these appendages, and all of them curve towards the distal end of the pinna, and not backwards over the gonangia.

HALICORNOPSIS, *Bale.*

(*Azygoplon*, Allman.)

Hydrocladia pinnately arranged; a fixed anterior sarcotheca adnate to the hydrotheca, laterals absent.

Gonangia not protected by phylactocarps.

This genus, which was first described by me in the Journal of the Microscopical Society of Victoria for 1882, differs from

Halicornaria simply in the absence of the lateral sarcothecæ. The species on which it is founded, *H. avicularis*, had been previously described by Kirchenpauer under the same specific name, but, as he could not find the lateral sarcothecæ, he described them as minute. The *Azygoplon rostratum* of the "Challenger" Report is the same species.

DIPLOCHEILUS, *Allman.*

Hydrocladia pinnately arranged; hydrothecæ provided with an outer calycine envelope; mesial sarcotheca not adnate to the hydrotheca, laterals absent.

Gonosome unknown.

This genus is distinguished by the duplicature of the hydrotheca-walls. *D. mirabilis*, the only species, has the mesial sarcotheca in the form of a concave disc, with a perforation in the centre. Its affinities are with the Eleutheroplea quite as much as with the Statoplea.

STREPTOCAULUS, *Allman.*

Hydrocladia uniserial, spirally disposed round the stem; trophosome otherwise as in Aglaophenia.

Gonosome unknown.

This genus is distinguished from all other Statopleans by the spiral and uniserial disposition of the hydrocladia, and is the only genus yet known in the sub-family which has the hydrocladia disposed otherwise than pinnately.

III.—GENERAL NOTES ON AUSTRALIAN HYDROIDS.

CAMPANULARIA RUFA, *Bale.*

This species resembles *Laföea halecioides*, described by Allman in the Report of the "Porcupine" expedition, but may be distinguished by the stem-processes from which spring the hydrothecæ, and which are much thicker than the pedicles of the latter species. There is also a distinct, though narrow, floor to the hydrotheca.

LINEOLARIA FLEXUOSA, *Bale.*

The gonangia of this species, hitherto unknown, may be defined as follows:—

Gonothecæ broadly elliptic, very convex above, with irregular transverse rugæ; aperture rather large, terminal, looking upward; margin elevated and expanding, operculate; a number of long, erect spines (usually somewhat over 20) on the upper side of the gonotheca, about equidistant from each other.

The hydrophyton often commences to grow in a tolerably regular fashion, giving off alternate pinnately-disposed branches, and afterwards forming an irregular network. To the naked eye it resembles very delicate metallic tracery. Most commonly the polypary is more or less invested by minute diatoms and other adventitious matter; but when this is not the case—as in the newly-formed portions—the structure is perfectly clear and transparent, and of such tenuity as to resemble a soap-film. When seen by reflected light it is more or less iridescent.

Sertularia bispinosa, *Gray.*

It is noticeable that in this species the older portions of the hydrocaulus are decidedly coarser and stouter than the more recently formed distal portions, a condition which I have not observed in the allied species *S. operculata.*

I have omitted to mention that Professor D'Arcy W. Thompson argues in favour of the identity of the two species, and cites Kirchenpauer's *Dynamena fasciculata* (which he considers to be Gray's *D. bispinosa* under another name) to show that there is no more than a varietal difference. This appears, however, to be a misconception, for Kirchenpauer's species is absolutely identical with our common form of *S. operculata,* which differs from the true *S. bispinosa* in having the calycles adnate for the greater part of their length, and in the form of the gonothecæ.

Such specimens as I have seen of *S. bispinosa* may be readily distinguished from *S. operculata* by the touch alone, as its coarser habit and sharper serrulations (caused by the more projecting hydrothecæ) give it a peculiar harshness, which is very characteristic.

Mr. H. Watts has collected this species at Warrnambool.

Sertularia trispinosa, *Coughtrey.*

A specimen of this species was collected by Mr. H. Watts at Warrnambool many years since. It has not been recorded from any other Australian locality.

SERTULARIA LOCULOSA, *Busk.*

I have described this species in the "Catalogue" as being occasionally pinnate, but have now no doubt that the supposed pinnate specimens belong to a different species—namely, the *S. Australis* of Kirchenpauer. So far as is known at present, *S. loculosa* has only occurred in the simple form.

SERTULARIA AUSTRALIS, *Kirchenpauer.*

Some specimens of a Sertularian which I received from Mr. Maplestone, and considered a pinnate form of *S. loculosa*, are, I believe, to be referred to the above species. By comparing the figure of a variety of *S. loculosa* which is given in the "Catalogue" (Plate IV., fig. 6) with that of *S. Australis* (Plate VIII., fig. 7), it will be seen that there is no noticeable difference in the form of the hydrothecæ; but specimens of the latter species which I have since collected at Williamstown have hydrothecæ which are almost entirely without the abrupt bend in the middle, and are provided with shorter teeth. The species is evidently a close ally of *S. divergens* and *S. tenuis*, from which it differs mainly in the larger and stouter internodes and hydrothecæ. As in those species, the internodes are comparatively wide below the hydrothecæ, and slender and elongated above, with slender joints. Though the species is usually pinnate, specimens of simple habit are occasionally met with.

SERTULARELLA JOHNSTONI, *Gray*, sp.

Under this name I have included two rather distinct forms—one (from New Zealand) with the hydrothecæ somewhat narrowed towards the aperture, or sub-conical, and with the gonangia narrow in proportion to their length, and with about fourteen annulations; the other, common in Bass' Straits, rather stouter, with tubular hydrothecæ, and the gonangia larger, proportionally broader, and with not more than about eight annulations. Dr. Kirchenpauer considers that in the type form the long, closely-ringed gonangia are associated with completely tubular hydrothecæ, and he describes as a new species (*S. purpurea*) a form which differs little, if at all, from the New Zealand one mentioned above, the free part of the hydrothecæ being, perhaps, slightly shorter. Professor Allman, however, describes the hydrothecæ of *S. Johnstoni* as being slightly narrowed towards the aperture, and Mr. Coughtrey calls them conical or sub-conical. I have no doubt, therefore, that my New Zealand specimens are the true *S. Johnstoni.* With regard to the Bass' Straits form, its tubular hydrothecæ, and the distinct form of its gonangia, entitle it to rank as a distinct variety, perhaps even as a distinct species. It is stated, however, by Mr. Coughtrey that there is considerable variation among New Zealand specimens, the annulations of the gonangia differing greatly in number and closeness. Hence, I have not felt justified in establishing a new species on what might prove insufficient grounds. The *S. divaricata* of Busk differs from this form to a comparatively small extent, and may have to be united with it, as I have seen specimens which appeared intermediate.

Plumularia campanula, *Busk.*

The *Plumularia laxa* of Professor Allman ("Challenger" Report) is, I have no doubt, identical with the above species.

Plumularia Buskii, *Bale.*

I have described this species as having the median sarcothecæ fixed; this applies, however, only to the anterior ones, those above the hydrothecæ being movable.

Plumularia aglaophenoides, *Bale.*

It is suggested in the "Catalogue" that if the genus Diplopteron be retained, it should be modified so as to include this species. The suggestion, however, is no longer applicable, as the genus has since been merged by Professor Allman in Polyplumaria, the essential feature of which, according to the more recent definition, is the possession of an accessory ramulus springing from each pinna.

Plumularia effusa, *Busk.*

This species is the type of Allman's genus Acanthella, which is distinguished by the presence of spines or metamorphosed hydrocladia at the distal part of the branches. From the "Challenger" Report it appears that Kirchenpauer's description (which I have quoted in the "Catalogue") is erroneous in assigning only a single supracalycine nematophore to each hydrotheca, there being in reality a pair of laterals, as in the Eleutheroplea generally.

Were it not that the "Challenger" specimens have been identified by Mr. Busk and Professor Allman from actual comparison with the original types of *P. effusa*, it would be difficult to believe them the same. The figure in the "Report" represents a strong, coarsely-growing species, with very distinct pinnæ, and calycles conspicuous to the naked eye, as in the larger Aglaopheniæ; while Kirchenpauer's figure of *P. effusa* shows a slender form, in which not only are the hydrothecæ far too small to be seen without optical aid, but the hydrocladia themselves are so delicate as to be scarcely noticeable, like a fringe of very fine hairs. That this is the more correct representation is proved by a sketch of Mr. Busk's of a portion of the polypidom, which is precisely like Kirchenpauer's figure, except that the pinnæ are a fraction longer. The magnified figure in the "Report" also differs somewhat from that of Kirchenpauer, and from Mr. Busk's sketches, notably in the hydrothecæ being less ventricose, and in the direction of the folds in the hydrothecal internode. The nematophores are shown by Kirchenpauer as having the margin entire, while in the "Challenger" figure it appears sinuated or canaliculate. Here the inaccuracy is doubtless on Kirchenpauer's part, as all the allied species have canaliculate sarcothecæ; indeed, I have never met with an Eleutheroplean in which the structure was otherwise.

Plumularia cornuta, *Bale.*

This species might with propriety be placed in the genus Polyplumaria, which, as now modified, is distinguished by the presence of an accessory hydrocladium springing from the proximal part of each pinna, although in *P. cornuta* the accessory ramulus bears only a single hydrotheca, above which it terminates in a blunt point.

Plumularia Wattsii, n. sp.

Hydrocaulus monosiphonic, branched, attaining a height of about ten inches; stem very slender, almost equal in thickness throughout; branches numerous, small, disposed around the stem in an irregular spiral, about 1-16th of an inch apart, one on each stem-internode, close to the summit; sometimes bearing one or two small secondary branchlets as well as the pinnæ; pinnæ short, alternate, one borne close to the summit of each internode of the branches, divided into alternate longer and shorter internodes, of which only the former bear hydrothecæ. Hydrothecæ cup-shaped, expanding upward, rather short, adnate up to the margin, aperture at right angles with the pinna. Sarcothecæ bithalamic, canaliculate, slender at the base and movable; one below each hydrotheca, and one at each side above it; one between every two hydrothecæ, on the intermediate internode; one at the base of each pinna, and one on the lower part of each internode of the branches.

Gonothecæ borne in the axils of the pinnæ, long, rather narrow, smooth, tapering about equally to the base and to the small circular aperture.

South Channel, Port Phillip Bay, Mr. Hy. Watts.

This species may be readily distinguished by the long slender stem, with its small branches arranged at short intervals from base to summit. These branches are mostly less than an inch long, and, in the specimens which I examined, were stouter and darker in the proximal portions, from which the pinnæ had fallen off. A single branch examined separately bears some resemblance to a shoot of *P. setaceoides*, but the hydrothecæ are more expanding, and differ also in being adnate up to the margin, and in the horizontal aperture. The fold or wrinkle which in *P. setaceoides* comes between the hydrotheca and the anterior sarcotheca is generally absent or slightly marked in the present species, and the sarcotheca is not so near the hydrotheca as in *P. setaceoides*, the internodes being longer.

Plumularia obliqua, *Saunders*, sp.

I have found branched specimens of this species on seaweed washed up on the beach at Williamstown.

Plumularia producta, *Bale*.

This species partakes of the characters of both the Statoplea and the Eleutheroplea. To the former group it is allied by the anterior position of the intrathecal ridge, a feature common to many Statopleans, while in those species of Plumularia which have a more or less distinct ridge it is posterior in position. The fixed anterior sarcotheca is not in contact with the calycle, and agrees generally with the same organ in many Plumulariæ, but the laterals, which are usually more distinctive, appear to be totally absent in this species. It should therefore probably be placed in a new genus, which, however, cannot be satisfactorily defined at present, owing to the absence of the gonosome.

AGLAOPHENIA PARVULA, *Bale*.

The variation of the structure of the corbula in this species is paralleled by that of *A. filicula* (Allman), a closely-allied, but larger, species. Professor Allman thinks it probable that in *A. filicula* the closed corbula is the normal form, and that the occurrence of corbulæ with the leaflets separate is an occasional irregularity. Doubtless the open corbula, which in *A. parvula* is of comparatively rare occurrence, is a reversion to an ancestral type. The closed corbula of this species has a supernumerary rib or leaflet, as in *A. filicula*, but with the important difference that in the latter species it springs, like the other leaflets, from the rachis, while in *A. parvula* it is a secondary growth, given off from the first leaflet of the corbula just above the base, and almost at a right angle; it therefore runs forward about parallel with the rachis of the corbula. It is not present when the corbula is open.

AGLAOPHENIA DIVARICATA, *Busk*.

In *A. divaricata*, as well as in some other species, the proximal part of the branches is destitute of pinnæ for a distance about equal to the length of the pinnæ on the main stem, and this portion of the branch bears along the front a central series of sarcothecæ, which in *A. divaricata* are very large. The bare proximal part of the branch is separated from the remainder by a long oblique joint. Small unbranched specimens are generally monosiphonic throughout, the stem not assuming the compound state until the hydrophyton is considerably advanced in growth.

AGLAOPHENIA LONGICORNIS, *Busk*.

This species is rather variable in the form of the hydrotheca-margin, which is represented by Professor Allman as only slightly elevated and rounded at the sides, while Mr. Busk describes the hydrotheca as having on each side a broad angular lobe. Sometimes these lobes run up to an acute point. The margin is sub-crenate, but only towards the back, and there is a small tooth where the side joins the lateral sarcotheca, by which it is often concealed when the latter is erect. Between the lateral sarcothecæ the back of the hydrotheca usually has two deep, narrow sinuses, with a long, narrow tooth between them, but they are sometimes comparatively shallow. The back of the hydrotheca can only be properly seen in front view when the hydrotheca is tilted forward. There is a deep inflection below the recurved aperture, not consolidated into an intrathecal ridge, but projecting so far into the hydrotheca that it is conspicuous in a front view, its inner margin having a bidentate form at the centre.

AGLAOPHENIA HUXLEYI, *Busk.*

In this species the hydrocladia are replaced at the distal ends of the branches by hollow spines without hydrothecæ, as first pointed out by Professor Allman, who has made the species the type of his new genus Acanthocladium. The figure of the hydrothecæ in the "Challenger" Report is erroneous in several particulars, noticeably in representing the margin as entire, while in reality it has a broad, rounded sinus at the back; in omitting the anterior tooth, which, though not large, is distinct and characteristic; and in showing the anterior sarcotheca as a long slender spine, closed throughout, whereas its true form is, in lateral view, remarkably beak-like, very stout where it joins the hydrotheca, and tapering rapidly upwards, with the point expanded laterally, while it is open on the distal side from base to summit. All these features are correctly characterised in Mr. Busk's original description, except that the open condition of the sarcotheca is not mentioned. This, however, is not apparent in an ordinary view, but on looking down on the hydrotheca from above it is easy to trace the opening down the sarcotheca, and to perceive that one of the margins overlaps the opposite one near the top. The expanded summit is usually, but not always, finely crenate. The crenations of the hydrotheca margin are much more pronounced in the "Challenger" figure than in any of the specimens which I have met with. The anterior intrathecal ridge attains its fullest development in this species, starting from the base of the mesial sarcotheca and projecting downward more than half-way through the hydrotheca, which it divides into two chambers. The posterior ridge is quite rudimentary.

Professor Allman has figured the corbula of this species, the ribs of which are curved filiform processes, armed with a single series of small sarcothecæ. Each has a hydrotheca projecting from it near the base, these hydrothecæ constituting the "single branches" mentioned by Mr. Busk.

In the "Challenger" Report the branches of this species are described as being bifariously disposed on the stem; but this is an oversight, as, indeed, is made apparent by the figure, which shows them as given off in several different directions. Their disposition is very regular, and perfectly uniform in the specimens which I have seen from two different localities. The main stem is distinctly flexuous, and from each angle springs a branch. The branches, however, are not in the same plane, but are arranged spirally round the stem, so that every four branches form a complete whorl, there being thus three longitudinal series up the stem.

AGLAOPHENIA PHŒNICEA, *Busk.*

I have no doubt that the *Lytocarpus spectabilis* of the "Challenger" Report is identical with the type form of *Aglaophenia* (*Lytocarpus*) *phœnicea*, though the form figured in the Report is of stronger and coarser habit than any of my specimens. Professor Allman gives a figure of the gonangial pinna, or nematocladium, which agrees in essential points with the same part in a Port Darwin specimen, the only one which I have found fertile. The first internode bears a hydrotheca, the next a gonangium, and the remainder of the pinna is armed with sarcothecæ, and recurved over the rachis. As Professor Allman points out, the gonangium springs from an elevation of the internode, which has two lateral sarcothecæ on the distal side of it, and a median one in front. This elevation evidently represents a hydrotheca, to which it bears a considerable resemblance when seen in front view after the gonangium has been removed, the point of attachment representing the aperture of the hydrotheca. A peculiarity presents itself in my specimen which is not shown in Professor Allman's figure—namely, that the first sarcotheca above the gonangial internode, which is on the proximal side of the nematocladium, is unpaired, the space opposite it on the distal side being vacant, while all the other sarcothecæ to the end of the pinna are in pairs opposite each other.*

* Several species of Aglaophenia, with open corbulæ, have the first and second sarcothecæ on the nematocladia unpaired, but in these the vacancies are on the proximal side—*A. divaricata*, *A. plumosa*, &c.

I have also observed that the hydrotheca which occupies the first internode of each nematocladium has one of its supracalycine sarcothecæ (that nearest the rachis) much smaller than the other, sometimes almost rudimentary. In the structure and position of the intrathecal ridge this species agrees with *A. Huxleyi.*

Though some of the forms which I have assigned to this species differ considerably from each other, I cannot find definite grounds for separating any of them unless the gonosomes should prove different. The remarkable variation in the direction of the lateral sarcothecæ must have presented itself in Mr. Busk's specimens, since he describes them as free and projecting, while in some of his sketches they are shown erect and adnate. The fact that they are frequently directed towards the back of the pinna no doubt accounts for the similar direction of those on the nematocladia, and it is to be observed that this backward direction obtains in the nematocladia of Professor Allman's specimens, and also in that from Port Darwin, though in each of these instances the supracalycine sarcothecæ are, for the most part, nearly erect and adnate.

The pinnately-disposed branches resemble those of *A. divaricata* in having the proximal part free from hydrocladia, and provided with a median series of sarcothecæ.

Kirchenpauer's *A. rostrata* is, I believe, the same as this species; also a Plumularian figured by Mr. Hincks in the *Popular Science Review* for July, 1874.

AGLAOPHENIA LENDENFELDI, *n. sp.*

(*A. Kirchenpauri*, Lend.)

I propose the above name for the species described by Dr. von Lendenfeld as *A. Kirchenpauri*, the latter name belonging properly to another species—the *Plumularia Kirchenpauri* of Heller (Zoophyten und Echinodermen des Adriatischen Meeres). The description of *A. Lendenfeldi*, with full illustrations, will be found in the Proceedings of the Linnean Society of New South Wales, Vol. IX., Part 3.

HALICORNARIA ASCIDIOIDES, *Bale.*

I have omitted to mention in the "Catalogue" the locality in which this species was found—namely, Queenscliff.

HALICORNARIA FURCATA, *Bale.*

The remarks in the "Catalogue" respecting this species might lead to the supposition that the axillary hydrothecæ are borne directly on the stem, but this is not the case. Where the stem bifurcates a single hydrotheca usually projects from the axil, but it is supported by a true hydrocladium, which, however, consists of a single internode only.

HALICORNOPSIS AVICULARIS, *Kirch.*

Azygoplon rostratum of the "Challenger" Report is the same as the species which I have described under the above name, and I have no doubt of the specific identity of Kirchenpauer's *Aglaophenia avicularis*, though Professor Allman is not satisfied on this point, owing to an apparent difference in the mesial sarcotheca; a difference, however, which seems to me to depend merely on a slight inaccuracy in Kirchenpauer's figure, principally in making the sarcothecæ appear tubular. The interruption between the upper and lower parts of the sarcotheca is often much less conspicuous than in Allman's figure, and doubtless it was a specimen in this condition which was figured by Kirchenpauer (as also by myself in the "Catalogue").

I have erroneously described this species as monosiphonic, (an error into which Professor Allman has also fallen), it being in reality polysiphonic, as described by Kirchenpauer. The mistake is easily explained by the fact that the fascicled structure only extends to the lower part of the stem and the larger branches, so that all the smaller branches and the distal portions of the larger ones (and in young specimens, such as I had principally examined, the whole hydrophyton) are really monosiphonic. The species is, moreover, more closely allied to those which are monosiphonic in habit than to the ordinary fascicled forms, since the branches spring directly from the internodes of the stout jointed stem or larger branches, and not, as in those species, from the supplementary tubes which are added to them. Each branch has its origin at the side of the stem or larger branch, immediately opposite a hydrocladium.

IV. Remarks on Recent Publications.

The Australian Hydromedusæ.—By R. von Lendenfeld, Ph.D. (from the Proceedings of the Linnean Society of New South Wales, Vols. IX. and X.).

Dr. von Lendenfeld's work is an important contribution to the history of the Australian Hydroida, containing a detailed system of classification, a list of previously-described species, with references and descriptions of many new species, most of which are illustrated by admirable figures. The life histories of some of the species have been worked out, and their histology carefully studied and illustrated.

The species cited or described in Dr. von Lendenfeld's work belong to a wider area of distribution than that which is represented in the "Catalogue of the Australian Hydroid Zoophytes." From the author's remark regarding a New Zealand species, to the effect that I appeared to doubt its habitat, as I had omitted it from the "Catalogue," it is evident that he has overlooked the remarks on distribution, which show that the Australian region, as represented in the "Catalogue," comprises only the continent and the seas immediately adjacent, not including New Zealand. Dr. von Lendenfeld, on the other hand, includes "within the Australian area the south coast of New Guinea, Fiji, New Zealand, Australia, and Tasmania, and the islands south-west of Fiji;" but in enumerating the species which have been described, he has omitted several which are found within these limits, and which are included in the following list:—

Thuiaria monilifera, Hutton, sp. *Sertularia monilifera*, Hut., T.N.Z.I., V.; Coughtrey, T.N.Z.I., VII.; D'A. W. Thompson, An. and Mag. Nat. Hist., Feb., '79; *Thuiaria cerastium*, Allman, Journ. Lin. Soc. Zool., XII. N. Zealand.

Thuiaria subarticulata, Coughtrey, T.N.Z.I., VII.; D'A. W. Thompson, An. and Mag. Nat. Hist., Feb., '79; *T. articulata*, Hutton, T.N.Z.I., V. (not Johnston); *T. bidens*, Allman, Journ. Lin. Soc. Zool., XII. N. Zealand.

Thuiaria dolichocarpa, Allman, Journ. Lin. Soc. Zool., XII.; D'A. W. Thompson, An. and Mag. Nat. Hist., Feb., '79; *T. Zelandica*, Gray, Dief., N.Z.; Quelch, An. and Mag. Nat. Hist., April, 1883. N. Zealand.

Sertularella robusta, Coughtrey, sp. *Sertularia simplex*, var. (?), Coughtrey, T.N.Z.I., VII.; *S. robusta*, Coughtrey, T.N.Z.I., VIII., An. and Mag. N.H., Jan. 1876. N. Zealand.

Sertularella episcopus, Allman, Journ. Lin. Soc. Zool., XII; *Sertularia fusiformis*, Hutton, T.N.Z.I., V.; Coughtrey, T.N.Z.I., VII.; *S. longicosta*, Coughtrey, T.N.Z.I., VIII. N. Zealand.

Sertularella integra, Allman, Journ. Lin. Soc. Zool., XII. N. Zealand.

Sertularella exigua, D'A.W.T., An. and Mag. N. Hist., Feb., '79. N. Zealand.

Sertularella fruticosa, Esper, sp. *Sertularia fruticosa*, Esper, Hist. des Zooph. suppl.; *Sertularia laxa*, Lk., An. s. Vert.; *Sertularella fruticosa*, D'A.W.T., An. and Mag. Nat. Hist., Feb., '79. N. Zealand.

Selaginopsis Novæ-zelandiæ, D'A.W.T. *Pericladium Novæ-zelandiæ*, D'A.W.T., An. and Mag. N. Hist., Feb., 1879. N. Zealand.

Desmoscyphus Buskii, Allman, Journ. Lin. Soc. Zool., XII. N. Zealand.

Halecium delicatulum, Coughtrey, An. and Mag. Nat. Hist., January, 1876. N. Zealand.

Hydrallmania (?) *bicalycula*, Coughtrey, An. and Mag. Nat. Hist., Jan., 1876. N. Zealand.

Aglaophenia Banksii, Gray, sp. *Plumularia Banksii*, Gray, Dief. N.Z. N. Zealand.

Aglaophenia Huttoni, Coughtrey, sp. (not Kr.). *Plumularia Banksii*, Hutton, T.N.Z.I., Vol. V. (not Gray); *P. Huttoni*, Coughtrey, T.N.Z.I., VII. N. Zealand.

Aglaophenia Huttoni, Kirch. (not Coughtrey). *Plumularia pennatula*, Hutton, T.N.Z.I., V. (not Lamx). N. Zealand.

Aglaophenia incisa, Coughtrey, sp. *Plumularia incisa*, C., T.N.Z.I., VII. N. Zealand.

Aglaophenia acanthocarpa, Allman, Journ. Lin. Soc. Zool., XII. N. Zealand.

Aglaophenia laxa, Allman, Loc. cit. N. Zealand.

Aglaophenia Vitiana, Kirch. Hyd.-Fam. Plumularidæ (description headed *Plumularia Vitiana* in error); *A. heterocarpa*, Bale, J.M.S.V., II. Fiji.

Plumularia oligopyxis, Kirch. Hyd.-Fam. Plumularidæ. Fiji.

Several species more or less doubtful.

Of the foregoing species Dr. von Lendenfeld (following Kirchenpauer) includes in his third addendum *T. monilifera*, under the synonym of *T. cerastium* (Allman); and *T. subarticulata*, and its synonym *T. bidens*, as two species; the rest are not mentioned.

Besides the Hydroid Zoophytes which are included in the "Catalogue," Dr. von Lendenfeld's work comprises the Tracho-medusæ, or Monopsea* of Allman, the graptolites, and the Hydrocorallinæ, the last of which are now ranked as a sub-order of Hydroida. (I may mention, however, that several Australian Hydromedusæ, which were described, and in some cases figured, by Péron and Lesueur, have been omitted from the list.) Dr. von. Lendenfeld adopts the name Hydromedusæ for the whole order, but it seems to me that the term Hydroida is preferable, as some of the members of the order do not, at any period of their existence, develop a medusoid structure. The sub-orders are Hydropolypinæ, or Hydroid Zoophytes whose generative zooids are never of a medusoid nature; the Hydromedusinæ, which have gonophores more or less medusiform in structure; the Trachomedusinæ, which are medusæ without a fixed polyp-stage; and the Hydrocorallinæ, or calcareous Hydroid corals. The first two of these sub-orders are equivalent to Allman's Eleutheroblastea, Gymnoblastea, Calyptoblastea, and Rhabdophora. Dr. von Lendenfeld claims that the Hydroida should be classified, like all other organisms, according to the structure of the adult, or the stage of existence at which reproduction is effected, and likens a system of classification founded on the polyparies to a scheme in which the dried skins of the larvæ of Cecidomya should be taken as indicating its systematic position, irrespective of the structure of the adult insect. In the construction of genera, however, Allman and Hincks, as well as other recent writers, have given due consideration to the structure both of the reproductive zooids and the polype-forms, although their primary divisions may be open to the objection that they are founded partly on larval forms, and may have to be superseded accordingly. Mr. Hincks does not rank the Trachomedusæ even as a sub-order, since he finds that species which have a larval polyp-stage may, as regards the medusa, be absolutely identical in structure with forms in which the medusa is developed direct from the ovum.

Dr. von Lendenfeld includes in the sub-order Hydromedu-

* I have inadvertently stated in the "Catalogue" that nothing is known of the Australian members of this group. Not having occupied myself with them, I had overlooked the fact that Péron and Lesueur, Haeckel, and other writers have described several Australian species of the sub-order, as well as of those families which are supposed to pass through a larval polyp-stage, but whose development has not yet been traced.

sinæ all those hydroids which exhibit traces of a medusoid structure in the sexual zooids, following to some extent the classification of Weissman. The latter author, however, finding that in some genera the medusoid structure is present in the female gonozooids, but not in the male, and arguing from the evident alliance between the latter and those of many other hydroids, places these also in the medusoid group, and finally includes in the same section all the Calyptoblastic and Gymnoblastic genera, leaving Hydra as the only representative of the group to which Dr. von Lendenfeld has applied the name Hydropolypinæ. This is on the assumption that all forms which exhibit medusoid affinities, or which appear nearly allied to such forms, are descendants of older types which were, in the adult stage, free medusæ. Dr. von Lendenfeld dissents from this view, pointing out that as the polyp-form is a more primitive type than the medusa, the genera which exhibit no trace of the latter form, or some of them, are at least as likely to be direct descendants of those primitive organisms as to have retrograded from intermediate medusoid ancestors. This argument cannot be gainsaid, and it seems to justify Dr. von Lendenfeld in ranking under Hydropolypinæ all those genera in which no medusoid modification exists. But both Weissman and von Lendenfeld agree that in genera where the gonozooids are modified medusæ, the species are to be considered as the retrograded descendants of true medusa-bearing species. This appears to me to be an assumption for which the evidence is inadequate, for it is quite possible that some of these species may be in process of gradual development *towards* the medusoid form, or arrested at particular stages of such a process, rather than retrograding from a more specialised condition.

Although it may be conceded that the sub-orders Hydropolypinæ and Hydromedusinæ are truly natural groups, the fact that in some genera it is difficult to decide whether the gonozooids have medusoid affinities or not is an obstacle to the general use of such a classification, at least until our knowledge of the histology of the various genera shall be more complete.

As already mentioned, a number of species have to be added to Dr. von Lendenfeld's list, and a few have to be deleted—for example, *Halicornopsis rostratum*, which is the same as *H. avicularis*, and *Selaginopsis mirabilis*, which has evidently been added to the list under a misapprehension.

A Record of Localities of some New South Wales Zoophytes, as determined by Dr. Kirchenpauer, communicated by Baron F. von Mueller, K.C.M.G., &c. Proceedings of the Linnean Society of New South Wales, Vol. IX., Part 3, November, 1884.

This is a list of a few species of Hydroids and Bryozoa sent to Europe by Baron von Mueller and named by Dr. Kirchenpauer. The species of hydroids are named as follows:—

Sertularella simplex, Hutton.—The species examined by Kirchenpauer is not the same as Hutton's, as is evident from the fact that in his last work Kirchenpauer includes it among the species with transversely wrinkled hydrothecæ, while Hutton's original species is smooth, and is, as I have elsewhere pointed out, identical with *S. polyzonias*. There is, however, a rugose species, originally described by Coughtrey as a variety of *S. simplex*, and afterwards named *S. robusta* by the same author, and this, or some similar species, is probably the one seen by Dr. Kirchenpauer.

Sertularella Johnstoni, Gray.

Sertularia lycopodium, Lamarck.—This specific name is merely a synonym of *S. elongata* (Lamouroux).

Sertularia millefolium, Lamarck.—This is supposed to be a synonym of *S. scandens* (Lamouroux), but it is impossible to identify the species with certainty from the description of either author. Both descriptions agree perfectly, so far as they go, with the small variety of *S. elongata*, and not with any other species known to me, but the specimens examined by Kirchenpauer may possibly belong to some other form.

Thuiaria cartilaginea, n. sp.—Described in Kirchenpauer's later paper.

Aglaophenia ramosa, Busk.—As I have mentioned in the "Catalogue," the species identified by Kirchenpauer with Busk's *P. ramosa* is really the *P. divaricata* of the same author.

Nordische Gattungen und Arten von Sertulariden von Dr. Kirchenpauer in Hamburg. Abhandlungen des Naturwissenschaftlichen Vereins in Hamburg, Band VIII., Abth. I., 1884.

This paper deals with the genera Selaginopsis, Thuiaria, and Sertularella, and with a group of species of which

Sertularia abietina and *S. filicula* are the types, which group the author proposes to separate as a distinct genus under the name of Abietinaria. There appear, however, to be no very definite grounds for this distinction, and on equally good foundations the genus Sertularia might be divided into fully half-a-dozen genera.

Among the species of Thuiaria and Sertularella a number from Australia are mentioned, several of which are described as new. I subjoin a few notes regarding some of them.

Thuiaria lichenastrum, Pallas, sp.—A form which occurs in a number of widely-separated localities, including Australia and Kamschatka, is referred to the above species by Kirchenpauer, who considers it perhaps synonymous with Busk's *Sertularia crisioides* (but not with the *Dynamena crisioides* of Lamouroux.) Busk's species, however (which I have described in the "Catalogue" under the name of *T. fenestrata*), is not the same as the present form, from which it may be readily distinguished by the vertical apertures of the hydrothecæ, and the four-toothed margin of the gonangium.

Thuiaria cartilaginea, K.—This species seems to resemble *T. lata* in some respects, but is peculiar in the absence of hydrothecæ from the stem and branches.

Sertularella reticulata, K.—A tricuspidate species from Bass' Straits, differing from *S. Johnstoni* in being inconspicuously toothed, and in the peculiar habit. It is dichotomously branched, with the branches all in the same plane, and often anastomosing, so as to form a net.

Sertularella sub-dichotoma, K.—A species from Bass' Straits and Magellan's Straits, described as differing from *S. Johnstoni* in its habit, which is not pinnate, but irregularly dichotomous. Busk's *S. divaricata* comes from the same localities as the above, but, though rather straggling, it is distinctly pinnate, and cannot therefore be identical with this species if Kirchenpauer's description is accurate.

Sertularella infracta, K.—This species, of which no figure is given, is said to differ from *S. Johnstoni* chiefly in its strong and robust habit, and in the form of the gonothecæ, which are "pear-shaped, short, thick, strongly inflated, and deeply ringed." The hydrothecæ are bent outward about the middle of their length. This feature, however, is not at all uncommon in *S. Johnstoni* and *S. divaricata*, the latter of which answers well to the description of *S. infracta*, and is very likely identical with it.

Sertularella purpurea, K.—This species (from the Chatham Islands) seems to me to differ little, if at all, from the ordinary New Zealand form of *S. Johnstoni.* Some of my specimens of the latter form agree with Kirchenpauer's in being of a beautiful purple-red throughout, but other parts of the same material are of the ordinary yellowish-brown colour, showing that the red tint is not a specific feature. I have met with the same variation of colouring in *Plumularia Buskii*, and Johnston mentions its occasional occurrence in some of the British Sertularians.

On Thuiaria zelandica, Gray. By J. J. Quelch, B.Sc. (Lond.), Assistant Zoological Department, British Museum (Annals and Magazine of Natural History, April, 1883).

The author of the above paper has ascertained from an examination of some of Gray's specimens of *Thuiaria zelandica* that the *T. dolichocarpa* of Allman is the same species, and proposes to abolish the latter name in favour of the older one, in which he has been followed by Kirchenpauer. To admit the claim of priority in such a case as this, however, would be to ignore the first principle of scientific nomenclature, which requires that for a specific name to obtain acceptance it must be accompanied by a description at least sufficient for the identification of the species with a reasonable degree of certainty. Gray's definition is entirely worthless, hence the species should continue to bear the name bestowed upon it by Professor Allman, who first gave a proper description of it, accompanied by careful figures. On the same principle Mr. Hincks retains the name of *Campanulina acuminata* (Alder) for a species which had been found to be identical with the earlier *C. tenuis* (Van Beneden), on the ground that Van Beneden's description was not sufficient to enable the species to be recognised.

It appears to me that the laws of nomenclature can only be properly appealed to in order to decide which of two or more proposed names has the better claim to acceptance, and not to interfere with names which have already become generally adopted. On the opposite plan we should be obliged, for example, to abolish the universally received Halicornaria of Allman in favour of Hincks' name, Gymnangium, applied previously to the same group.

Description of Australian, Cape, and other Hydroida, mostly new, from the Collection of Miss H. Gatty, by Professor Allman.

(Journal of the Linnean Society, 1885.)

The above paper (which was only received here after the completion of the foregoing observations) contains descriptions and figures of many new species from various parts of the world, including two for which Professor Allman has established new genera. Of one of these genera, Gattya, I have inserted a notice in its proper place among the Eleutheroplea; the other, Thecocladium, belongs to the Sertulariidæ, and is distinguished from Thuiaria by the fact that its branches spring from within hydrothecæ.

The Australian Hydroids which Professor Allman describes are for the most part new, but a few known forms are re-described and figured. I append notes on two or three of the species:—

Sertularella trochocarpa, n. sp.—This species appears in some respects intermediate between Sertularia and Sertularella, if an important feature of the latter genus be, as I have always considered it, the presence of a single hydrotheca only on each internode of the ramuli, instead of one or more pairs, as in Sertularia, or two unpaired series, as in Thuiaria. *S. trochocarpa* has two hydrothecæ on each internode, which are distinctly alternate; its general aspect is that of a Sertularella, and the gonothecæ are ringed and provided with a funnel-shaped mouth, as in some varieties of *S. Johnstoni* and its allies. Two Australian species of Sertularia have the gonothecæ ringed, but in these cases the summit is neither funnel-shaped nor toothed.

In all the species of Sertularella which have been hitherto well known and fully described, there is a single hydrotheca on each internode, except in the principal stems of some of the branched species.

Sertularia minima, Thompson.—From the relative position of the teeth of the hydrotheca in Professor Allman's figure it would appear to represent the back of the polypary. This would account also for the calycles not being shown in contact with each other, which is almost invariably their actual condition in the front of the polypary, except in the lowest pair or two.

The adnate condition of the opposite hydrothecæ would bring this species, as well as most of our other Sertulariæ, under the genus Desmoscyphus of Allman; but I have not been able to adopt this genus, owing to the inconstancy of the characteristic feature. In some of the species it is present, while in others most closely allied to them it is wanting; and there are several species which vary in this respect in different specimens. Very often the hydrothecæ at the distal part of a branch are adnate to each other, while those in the proximal portion are separated.

In describing this species (as well as *S. minuta*) I have fallen into a slight inaccuracy as regards the position of the gonangia, which spring from the basal part of the lowest internode, but from the side of it rather than behind, as stated in the "Catalogue."

Lytocarpus ramosus, n. sp.—This species would come under the genus Aglaophenia, as defined in the foregoing pages, and it appears scarcely distinct from *A. divaricata*, a somewhat variable species. The corbula is like those of *A. plumosa* (Bale) and *A. acanthocarpa* (Allman) in every essential point; but in those species the "ribs" are slightly flattened and less arched.

The specific name *ramosa* is preoccupied by the *Plumularia ramosa* of Busk, a species closely resembling the present both in the trophosome and the gonosome. There is also an *Aglaophenia ramosa*, the gonosome of which is unknown, among Allman's Gulf Stream Hydroids.

Plumularia ramosa (Busk), *P. divaricata* (Busk), and *Lytocarpus ramosus* (Allman) are all found in or near Bass' Straits, and it is not unlikely that on future investigation they may all prove to be varieties of one species.

Art. X.—*On Lightning Conductors.*

By Professor Kernot.

[Read 12th August, 1886.]

A properly constructed lightning-conductor acts in two different ways.

1st. It gradually and silently draws the electricity away from the clouds in the same way as a pointed wire in communication with the earth draws, or, as it is sometimes expressed, *sucks* the electricity away from the charged conductor of an ordinary frictional electrical machine. Every conductor that acts in this way is a public benefit, mitigating the severity of thunderstorms in the locality where it is situated. Hence it would be a perfectly reasonable and proper thing to erect conductors at the public expense upon all lofty buildings or other elevated points in the vicinity of a town. The effect of a single conductor would probably be imperceptible, or nearly so, in this respect; but the effect of a score or a hundred would be manifest in a marked diminution in the intensity of atmospheric electric phenomena over or to the leeward of the place where they were situated. In order to be efficient for this purpose a conductor should—first, be provided with one or more fine, sharp points at its upper termination; second, have its own electric resistance small; third, have a good earth connection.

2nd. When the building is actually struck by lightning, the conductor may be of great use by attracting the discharge to itself and away from other parts of the structure, and conveying it harmlessly to the earth. For this purpose it should—first, be so prominent as to necessarily receive the electric spark, no matter from what direction the electrified cloud travels; second, be of such sectional area as to convey the largest discharge likely to occur without being heated to such an extent as to fuse or become distorted; third, have its own resistance and that of its earth connection distinctly smaller than that of any water-pipe, gas-pipe, or other conducting mass in its vicinity.

In addition to the above, it is a wise precaution to connect the conductor with all the principal metallic masses in the building, to place it on the side of the building most likely to be moistened by rain, and, as far as possible, so to arrange it that any considerable charge of electricity in or upon any part of the building may be, so to speak, drained away as easily as possible. If these last requirements be attended to, little or no harm will result, even though the lightning should in the first case strike a part of the building some distance from the conductor.

Several years ago the Meteorological Society of England invited the co-operation of the Royal Institute of British Architects, the Physical Society, and the Society of Telegraph Engineers in a conference upon lightning conductors. The last-named societies responded to the invitation, and a number of delegates were appointed, amongst whom were Messrs. Latimer Clark, Preece, Ayrton, and Hughes, gentlemen whose eminence in the electrical world is unquestioned. The conference collected all accessible evidence, discussed the same at numerous sittings during the years 1878, 1879, 1880, 1881, and ultimately published a most valuable report, accompanied by a code of rules, for the construction and erection of conductors, together with replies to questions that had been widely circulated as to damage by lightning and efficiency of conductors.

Through the kindness of G. Watson, Esq., architect, Public Works Department, I am enabled to submit this valuable, but, unfortunately, little-known report, to the Royal Society of Victoria.

The code of rules is as follows:—

RULES.

1. Points.—The point of the upper terminal should not be sharp, not sharper than a cone of which the height is equal to the radius of the base; but a foot lower down a copper ring should be screwed and soldered on to the upper terminal, in which ring should be fixed three or four sharp copper points, each about six inches long. It is desirable that these points be so platinised, gilded, or nickel-plated as to resist oxidation.

2. Upper Terminals.—The number of conductors or points to be specified will depend upon the size of the building, the material of which it is constructed, and the comparative height of the several parts. No general rule can be given for this, but the architect must be guided by the

directions given at pp. 12 to 14.* He must, however, bear in mind that even ordinary chimney stacks, when exposed, should be protected by short terminals connected to the nearest rod, inasmuch as accidents often occur owing to the good conducting power of the heated air and soot in a chimney.

3. INSULATORS.—The rod is not to be kept from the building by glass or other insulators, but attached to it by metal fastenings. (See p. 11†).

4. FIXING.—Rods should preferentially be taken down the side of the building which is most exposed to rain. They should be held firmly, but the holdfasts should not be driven in so tightly as to pinch the rod, or prevent the contraction and expansion produced by changes of temperature.

5. FACTORY CHIMNEYS.—These should have a copper band round the top, and stout sharp copper points, each about 1 foot long, at intervals of 2 or 3 feet throughout the circumference, and the rod should be connected with all bands and metallic masses in or near the chimney. Oxidation of the points must be carefully guarded against.

6. ORNAMENTAL IRONWORK.—All vanes, finials, ridge ironwork, &c., should be connected with the conductor, and it is not absolutely necessary to use any other point than that afforded by such ornamental ironwork, provided the connection be perfect, and the mass of ironwork considerable. As, however, there is risk of derangement through repairs, it is safer to have an independent upper terminal.

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* Considerable difference of opinion has existed as to the area protected by each conductor. The latest French instructions, quoted on p. 13 of the Report accompanying the Code of Rules, say a point will "effectively protect a cone having the point for its apex and a base whose radius is 1·75 of its height." The English War Department instructions say that "no precise limit can be fixed to the protecting power of conductors. In England the base of the protected cone is usually assumed to have a radius equal to the height from the ground; but, though this may be sufficiently correct for practical purposes, it cannot always be relied upon."

† Page 11 of Report: "The evidence against the use of glass or other material in order to insulate the conductor is overwhelming, and insulation may be regarded as unnecessary and mischievous. The essentials are—(1) That the rod be attached to the building by fastenings of the same metal as itself; (2) that the fastenings be of adequate strength; (3) that they be of such a form as not to compress or distort the rod; (4) that they allow for expansion and contraction; (5) that they hold it firmly enough to prevent all the weight falling on any one bearing."

7. Material for Rod.—Copper, weighing not less than 6 oz. per foot run, and the conductivity of which is not less than 90 per cent. of that of pure copper, either in the form of tape or rope of stout wires, no individual wire being less than No. 12 B.W.G. Iron may be used, but should not weigh less than $2\frac{1}{4}$ lbs. per foot run.

8. Joints.—Although electricity of high tension will jump across bad joints, they diminish the efficiency of the conductor; therefore every joint, besides being well cleaned, screwed, scarfed or riveted, should be thoroughly soldered.

9. Protection.—Copper rods to the height of 10 feet above the ground should be protected from injury and theft by being enclosed in an iron pipe reaching some distance into the ground.

10. Painting.—Iron rods, whether galvanised or not, should be painted; copper ones may be painted or not according to architectural requirements.

11. Curvature.—The rod should not be bent abruptly round sharp corners. In no case should the length of the rod between two points be more than half as long again as the straight line joining them. Where a string course or other projecting stone work will admit of it, the rod may be carried straight through, instead of round the projection. In such a case the hole should be large enough to allow the conductor to pass freely and allow for expansion.

12. Extensive Masses of Metal.—As far as practicable it is desirable that the conductor be connected to extensive masses of metal, such as hot-water pipes, &c., both internal and external; but it should be kept away from all soft metal pipes, and from internal gas pipes of every kind.* Church bells inside well-protected spires need not be connected.

13. Earth Connection.—It is essential that the lower extremity of the conductor be buried in permanently damp soil; hence proximity to rain-water pipes and to drains is desirable. It is a very good plan to make the conductor bifurcate close below the surface of the ground, and adopt two of the following methods for securing the escape of the lightning to the earth. A strip of copper tape may be led

* It is recommended that the inlet and outlet pipes of large gas-meters be electrically connected together independently of the meter. The absence of this precaution has led to accidents in two very remarkable cases.

from the bottom of the rod to the nearest gas or water *main*, not merely to a lead pipe, and be soldered to it; or a tape may be soldered to a sheet of copper 3 feet x 3 feet, and $\frac{1}{16}$ inch thick, buried in permanently wet earth, and surrounded by cinders or coke; or many yards of the tape may be laid in a trench filled with coke, taking care that the surfaces of copper are, as in the previous cases, not less than 18 square feet. Where iron is used for the rod a galvanised iron plate of similar dimensions should be employed.

14. INSPECTION.—Before giving his final certificate, the architect should have the conductor satisfactorily examined and tested by a qualified person, as injury to it often occurs up to the latest period of the works from accidental causes, and often from the carelessness of workmen.

15. COLLIERIES.—Undoubted evidence exists of the explosion of firedamp in collieries, through sparks from atmospheric electricity being led into the mine by the wire ropes of the shaft and the iron rails of the galleries. Hence the headgear of all shafts should be protected by proper lightning-conductors.

(Signed)

W. GRYLLS ADAMS.
W. E. AYRTON.
LATIMER CLARK.
E. E. DYMOND.
C. CAREY FOSTER.
D. E. HUGHES.
T. HAYTER LEWIS.
W. H. PREECE.
G. J. SYMONS.
JOHN WHICHCORD.

A careful inspection of lightning conductors upon numerous public and private buildings in Melbourne reveals endless departures from the preceding rules, and leads to the conclusion that, as generally applied here, conductors are rarely as efficient as they might and ought to be, while in not a few cases they are so bad as to be a positive source of danger. The principal faults that have come under my notice are:—

1st. Blunt points. These impair the action of the conductor in silently discharging the atmospheric electricity.

2nd. Insufficient elevation above the rest of the building. In this case the building may be struck at points distant from the conductor. A common case is that of a roof 50 or 100 feet long, with a conductor at one or both ends not rising more than 5 feet above the ridge.

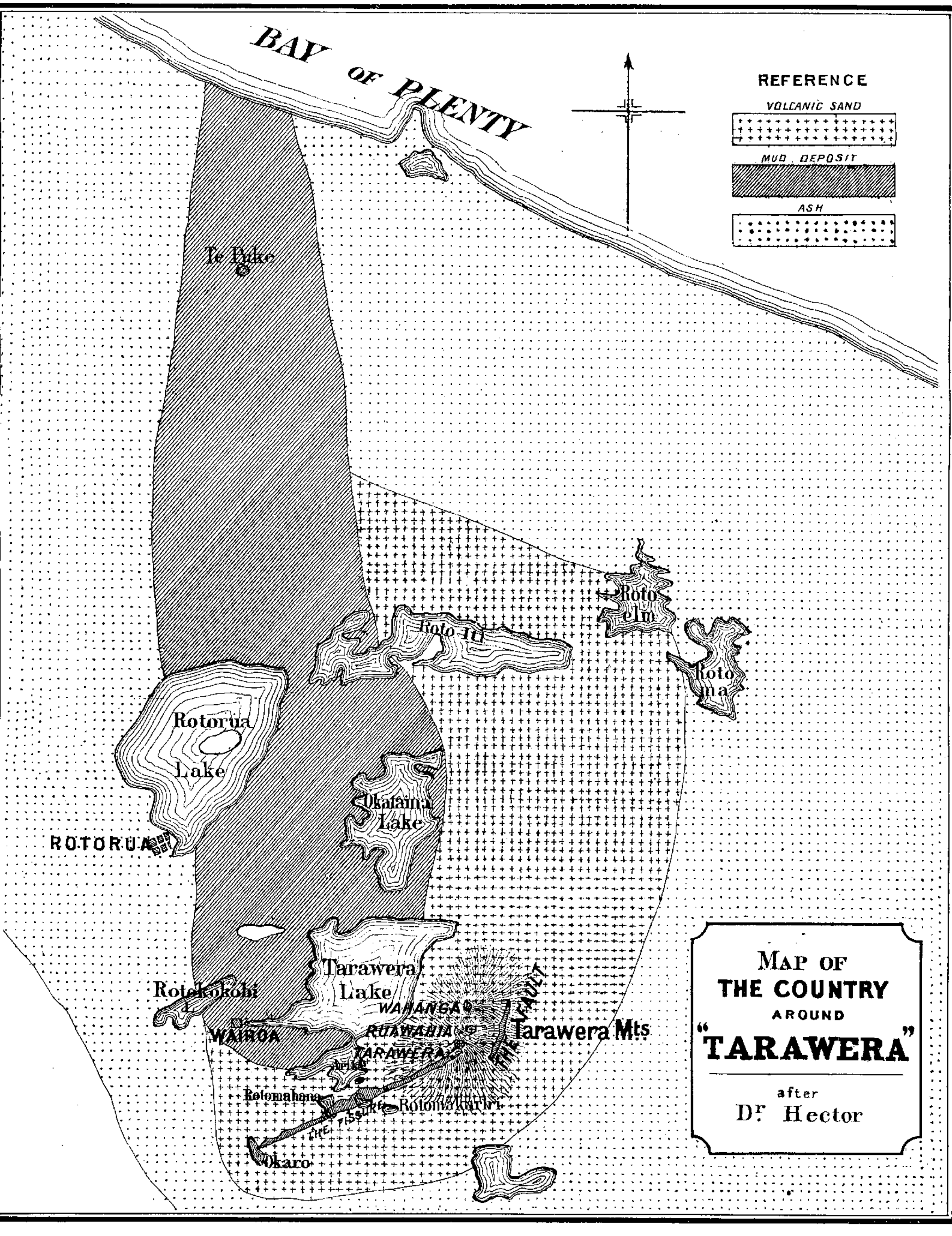
3rd. Numerous joints breaking the metallic continuity of the conductor. These joints may appear mechanically good, but be very defective electrically, especially when old and corroded. They impede the silent discharge, and increase the risk, in the event of actual stroke, of the electricity leaving the conductor and striking across to some other metallic mass.

4th. Insufficient sectional area. This is a most usual fault. Should such conductors be actually struck, they would fuse before the charge was carried off, leaving the remainder to force its way to some other conducting body. Many of our conductors are not more than one-third as large as they should be.

5th. Insulation. Instead of bringing the conductor into the closest contact with the building, many persons carefully insulate it. This in no way aids the conductor in fulfilling its functions, while it greatly enhances the danger should some other part of the building first receive the discharge.

6th. Bad earth connection. This is a common and most fatal defect. Owing to accidental damage, theft, or corrosion, many conductors do not reach the ground at all, but terminate a few feet above. These are most dangerous. They induce the discharge which otherwise would probably not have taken place, and cause a violent manifestation of electric energy at a place where it is likely to do much damage to life or property. Such a conductor should be either properly repaired or entirely removed. Further, some conductors which apparently reach the earth are so terminated that the resistance to the passage of electricity is greater than that of some water or gas-pipe in the vicinity. In this case a lateral discharge is likely to take place, with disastrous results, damaging brickwork or masonry, fusing gas-pipes and setting fire to the gas, or injuring or killing any person in the vicinity.

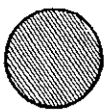
I do not wish to be an alarmist, but I feel it my duty to point out the extremely unsatisfactory state of the vast majority of lightning conductors in Melbourne, and to urge that a general inspection and renovation should take place under the direction of a competent electrician, who should


BAY OF PLENTY
REFERENCE
VOLCANIC SAND
MUD DEPOSIT
ASH
Te Puke
Roto Iti
Rotorua Lake
ROTORUA
Okataina Lake
Tarawera Lake
Rotokakahi
WAIROA
WAHANGA
RUAWAHIA
TARAWERA
Tarawera Mts
THE FAULT
Rotomahana
THE FISSURE
Rotomakariri
Okaro
MAP OF THE COUNTRY AROUND "TARAWERA"
after Dr. Hector

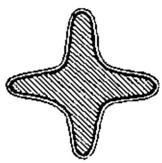
first see existing faults rectified, and then at intervals of, say, not more than three years, examine and test every conductor.

In conclusion, I would quote the following words from the report of the conference: "There is no authentic case on record where a properly constructed conductor failed to do its duty."

The subjoined diagrams illustrate the conductors at the Melbourne University. These are very much superior to many in use elsewhere; nevertheless they would all be condemned under the Code of Rules, and the newer type is distinctly inferior to those used on the oldest part of the building.



Old Conductors—Half-inch iron rod; area, ·196 square inch; joints every twenty feet; screw couplings.



New Conductors—Iron, covered with very thin copper; three contact joints every twelve feet; area, about ·15 square inch, of which about one-sixth is copper.

Art. XI.—*On the Official Reports of the Tarawera Outbreak, with Objections to some of the Conclusions drawn by the Government Geologist, Dr. Hector.*

By G. S. Griffiths, Esq.

[Read 9th September, 1886.]

In reading the official report of this outbreak, it will be noticed that Dr. Hector describes his chief object in visiting the scene of activity as being "to ascertain the exact locality, nature, and extent of the outbreak, and its probable consequences to the district."

The views that he formed after he had examined the district are summed up by him as follows:—He concludes that the eruption was (1) a purely hydrothermal phenomenon; (2) that it was not of deep-seated origin; (3) that it was a quite local movement; and he also tells us that the great fissure was the most characteristic feature of the outbreak.

What I propose to do is to discuss Dr. Hector's views as to the nature of the eruption as far as the facts disclosed in these two reports will enable us to do so.

We will, in the first place, consider the statement that it was a purely hydrothermal phenomenon.

Now, what is a purely hydrothermal phenomenon?

Must a phenomenon, to be termed purely hydrothermal, have heated water, and nothing else, as its cause, and also heated water, and nothing else, as its effect? If so, then hot springs and geysers alone are purely hydrothermal phenomena, and Dr. Hector's meaning must be that Tarawera was merely a geyser.

But it is certain that Dr. Hector might mean to describe a phenomenon of which the sole cause was heated water, although the visible effects included the emission of many kinds of matter besides steam and water. Such a phenomenon would be a volcano, and if I accepted Dr. Hector's words in this sense, then his meaning would be that the sole cause of the Tarawera outbreak was the action of heated water. But such a statement would be the merest truism, and therefore it is unlikely that he would make the assertion.

Consequently, it will be necessary to weigh the language of the context to enable us to decide whether he means to say that Tarawera was a mere geyser, or that the Tarawera volcano was actuated purely by steam.

Thus he tells us that it was a hydrothermal phenomenon, but upon "a gigantic scale." Now, if it were a geyser eruption, it certainly was one upon a gigantic scale; but if it were a volcano, its scale was not at all gigantic, but very ordinary. Therefore, from the use of this adjective we would infer that he is describing a geyser.

Again, he states that the outbreak was "not deep-seated." This raises the question as to whether volcanoes are ever superficial in their origin. I shall discuss this point further on, and at this stage I will only say that such a statement confirms the impression already made on my mind that a geyser, and not a volcano, is conceived of by the author of the report.

The use of these qualifying words in relation to the scale and to the origin of the eruption decides me that Dr. Hector, when he used the phrase "a purely hydrothermal phenomenon," meant to assert that Tarawera is a geyser, and not a volcano.

Now, what is the difference between a volcano and a geyser? They are alike as to their causes. Both of these forms of activity are due to the same agent. Each is a natural steam-engine. Each requires to have water in its chambers before it can operate, and without water can no more act than can a locomotive with a dry boiler. But if they agree in their motive-power, they differ greatly in the mode in which they eject solid matters; and they differ even more widely in the nature of the material ejected.

Geysers emit usually only water and steam, but occasionally they eject stones. Such stones are, however, always of superficial origin; they are rocks which have been torn out of the vent by the steam blast; they are derived from its throat, and not from its stomach. The ejectamenta of a volcano are, on the contrary, drawn mainly from its stomach—that is, they are principally of plutonic origin. Only a small proportion of the output is derived from the throat, and this part is ejected chiefly at the beginning of the outbreak, while the fissure is forming, or when the plug is being blown out. Therefore, the first difference between a geyser and a volcano is that the former ejects only steam and the materials of the neck, whereas volcanoes vomit the contents of their deep-seated reservoirs as well as the contents of their vents.

The second difference between them is a direct consequence of the first.

While the solid ejecta of geysers is unfused country rock, and never consists of lava, scoria, or ash, volcanoes eject all these materials, and the country rock from the neck is, as often as not, more or less fused.

Consequently, we should be able to decide as to whether Tarawera is a volcano or whether it is a mere geyser, as Dr. Hector contends, by an examination of its ejectamenta.

Both Dr. Hector and Mr. Percy Smith describe the materials erupted by Tarawera, and they tell us that 1800 square miles of country have been buried more or less deeply under sand, ash, and tuff, mingled with fragments of old trachytic lava, the latter being the country rock drilled out of the vent.

Dr. Hector also presents to us an analysis of the dust from Tarawera, and it is constituted as follows:—

	Obsidian Ash from Tarawera. (Dr. Hector's report.)	Obsidian.	Andesitic Lava.	Diorite or Syenite.	
Si. ...	59·37	60 to 80	59·75	54 to 59	59·83
Iron oxides ...	10·18	3 to 7	7·57	10 to 14	7·01
Al. ...	17·96	18 to 19	17·25	16 to 18	16·85
Manganese ...	traces	—	—	—	—
Ca. ...	5·98	1·1	6	6 to 7·5	4.43
Mag. ...	1·19	0·6	1·30	6	2·61
Phos. acid ...	traces	—	—	—	—
Water ...	2·21	—	1·0	—	1·29
Soluble salts ...	traces	—	—	—	—
Organic matter	·99	—	—	—	—
Alkalies ...	2·12	9·2	7·10	—	9·18

Now, we are sufficiently well-acquainted with the nature of volcanoes to be able to say that an obsidian ash of the composition given above has been derived from that variety of lava which has been named andesite, and that andesitic lava in its turn has been derived from a reservoir of molten diorite. I therefore give the elements of these rocks side by side with those of the ash, so that you may see at a glance their elementary kinship.* These three forms of the same substance (obsidian, andesite, and diorite) result entirely from their elements cooling under different conditions; but their fundamental agreement is disclosed in their identical composition. This volcanic dust consists of a mass of broken glass bubbles and spiculæ, which could not have been derived from the throat of a geyser, for it has required for its elaboration conditions available only at great depths. If Tarawera has ejected an ash which must have been elaborated at great depths, then we must admit that it must have a deep-seated origin; but we have already noted that Dr. Hector denies this. He declares that its origin is not deep-seated, but he neither tells us what he

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* The relationship of the various plutonic rocks to the volcanic forms is stated thus by Professor Judd :—

	Granitic Forms.	Lava Forms.	Glassy Form.
Acid ...	Granite ...	Rhyolite ...	Obsidian
Intermediate	Syenite ...	Trachyte ...	Do.
	Diorite ...	*Andesite* ...	*Do.*
	Miascite ...	Phonolite ...	Do.
Basic ...	Gabbro ...	Basalt ...	Tachylyte

believes to be its absolute depth or what he would call deep or shallow. This phrase of his, then, as descriptive of position, is of vague and uncertain meaning, for depth is relative and ideas differ. The depth that would be great for a shaft would be shallow for a volcano, and, compared with the globe-bulk, the greatest sea-depth is superficial. Now, it is impossible for any one to prove, in absolute measure, what the position of the focus is; but I think I have shown that its depth must be that of a reservoir capable of holding for a long period molten diorite mixed with water at a white heat. Therefore, it seems to me that Dr. Hector can establish his contention of a shallow origin for Tarawera only by showing us that diorite can be elaborated under a crust which, judging by an analogy, is too thin to afford it either great pressure or a hermetic cover, and within a furnace the wall of which is not thick enough to retain the heat required to fuse its materials.†

Taking into consideration the plutonic nature of the ejected materials, therefore, I am unable to accept Dr. Hector's conclusion that Tarawera is a geyser eruption.

But when we have decided in our own minds that it is a volcano and not a geyser, there is still room left for further inquiry into its nature, as volcanoes are of several types, distinguished from each other by important differences. For instance, Dr. Hector does not notice in his report what appears to me to constitute the essence of the nature of this eruption—namely, that it is a fissure eruption and not a crater eruption. Certainly, he points to the fissure, and terms it "the most remarkable and characteristic feature of the late eruption;" but while he recognises the greatness of the feature as a part of the landscape, he does not say a word to indicate that he recognises the real importance of the fissure to rest upon the fact that it supplies the key which explains a great enigma in the mechanics of Tarawera, which otherwise would puzzle us.

This enigma may be stated as follows:—The Tarawera vent was charged with lava; the vent was so low in position that it was level with the lake; the lava was charged with an abundance of interstitial steam, and yet no lava was erupted. Why, then, with all these favourable conditions present, was there no emission?

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† Judd estimates that the Granites have consolidated under the pressure of depths varying between 30,000 feet and 80,000 feet. *Volcanoes*, p. 253.

We can understand why Cotopaxi erupts rarely, because we know that the lip of its crater is placed more than 19,000 feet above the level of its reservoir, and we allow for the enormous resistance which must be overcome before the column of lava can be forced up to the top of so lofty a chimney. But at Tarawera there was no chimney—the vent was an open chasm in the valley floor.

Again, we can understand a volcano in the Solfatara stage not erupting, for when in that stage the water has run short, or the fires have got low. But here steam was present in such abundance as to lead Dr. Hector to describe the affair as " a purely hydrothermal phenomenon."

And, again, we could understand it if, with an abundance of steam and with an easy exit, there was no lava present. But we know that there was an ample supply here, because every uprush of steam loaded the air with obsidian, which is the froth of bubbling lava. Why, then, I repeat, was no lava erupted at Tarawera ?

To make the explanation clear, let us remember our former simile. I said that a volcano was a natural steam-engine. Now, a steam-engine will not work well, will not generate a high horse-power, however well supplied with water and fire, if its boiler have a leak; and if the leak be a large one, it will wholly disable the engine, so that its steam, instead of being utilised, will escape idly in great white clouds, and with a prodigious roar. Such, then, exactly represents the course of events at Tarawera. The subterranean steam burst through the crust that confined it. The crust had no weak spot in it, such as the small circular plug which is blown out of the vent when Vesuvius, Etna, Hecla, or Tongariro erupt. It had, therefore, to break through a sound crust, and it did so with a long rent.

Where there is an ordinary crater-vent, such as these volcanoes named have, its size just suffices to give gradual relief to the high-tension vapour imprisoned below, but it is not large enough to permit of a free escape. Consequently, the interstitial steam has a struggle to reach the vent. It expands as it reaches the region of lessening pressure, and the expanding bubbles, as they hurry through the passages, crowd before them a great volume of liquid aërated lava, which thus boils over the lip in exactly the same way that water or milk will do. But the Tarawera vent was not a circular crater of limited size, but a fissure eight or nine miles long, and, in places, one mile wide. Such a vast chasm has an effect which corresponds to that of the leak in the locomotive boiler, or to that of the rupture of an aneurism in some great artery. It provides the lava with such an extent of free surface that its steam escaped without effective effort—that is, without accumulating anywhere hydrostatic pressure enough to lift the lava over the lip. Thus the pumping-up power is lost, and only lava bubbles escape, and these, saturated with high-tension steam, explode into dust at the moment of complete relief.

It will be seen, therefore, that the size of the rupture fully accounts for the absence of a lava flow, and is the key to the character of the outbreak.

Tarawera will become notable because it is an example of the comparatively rare fissure-type of eruption, instead of being one of the familiar cone-and-crater type.

It is now believed that every volcano has commenced as a fissure. The fissure is sealed up when the first great steam escape has ceased, excepting at one or two points where small cones form and let off the residue, and then become plugged up in their turn. In time steam accumulates again, and ultimately a second phase of eruptivity commences. In this revival of activity the fissure does not reopen, but only the cones, which this time erupt lava and ash, and grow rapidly in size, so that in time the old fissure is buried under either a chain of small craters or under one large volcano. Whether or no such a development as this is to be the sequel of Tarawera only the future can tell us.

The meteorological conditions which accompanied the eruption are hardly referred to in the official reports.

From other sources we gather the interesting fact that it occurred at a time when an area of barometrical depression passed over that end of New Zealand. Mr. Cheeseman, the Government Meteorologist, states that at 4 a.m. on June 9th the barometer stood at 30·27, but that it then fell until it touched 29·94, or a drop of one-third of an inch, at which it stood until 4 a.m. of the 10th, the morning of the outbreak, when it began to rise again.

Unfortunately, we have no barometrical readings from the immediate neighbourhood of the disturbance, but the New Zealand papers give a singular story, which points to a heavy fall at Wairoa. It is stated that during the bitterly cold morning when the eruption was at its climax, some of M'Rae's party lit a fire to make a drink of cocoa, but that at the end of three-quarters of an hour, and although the water in the billy bubbled, it never became heated nearly up to the ordinary boiling point, and the men, struck with the strangeness of the phenomenon, concluded that it was an "uncanny" omen, and so abruptly abandoned their task.

If this story has a substratum of truth—as it well may have—it would indicate an excessive barometrical fall over Wairoa during the eruption. Such a fall might have been due to the enormous volume of superheated steam and gas which was projected into the atmosphere, and which, accumulating round and banking up over the vent, as a dome-shaped cloud, would give to the several planes of pressure enveloping it, a sharp, short, quâ-quâ-versal dip, down which the cold and dense, and therefore heavier strata of superincumbent air, would quickly slide away to every point of the compass, piling up at the bottom of the slope, as an atmospheric talus, and so forming a peripheral ring of higher pressure round the volcano, but at a little distance from it. The displacement of such a volume of heavy air by an equal volume of attenuated air would register itself at the earth's surface below it in a fall of mercury, and it would lower the boiling point of water for every altitude within the same area. Thus it would render the newspaper story quite possible.

Again, it is well to remember that the abrupt creation of such a disposition of the atmosphere would account for the tornado blast which played such havoc near the volcanoes during the second phase of the eruption. For, over the fissure, the ascending vapours must have operated as an atmospheric chimney, and this would create a powerful indraught of low-level air, and the enclosing ring of high-pressure—that is, the atmospheric talus before suggested—would, if it existed, increase the indraught.

It would be very interesting to learn all the wind movements which occurred that morning round the volcanoes.

The official reports give the changes at Wairoa and Rotorua only; but these two places are situated in the same quadrant of a cyclone centred over Tarawera, and the absence of settlement in the surrounding region will render it almost impossible to get the information desired.

Still, we ought to get some information as to the direction taken by the great tornado from the bearings of the fallen trees, and some more general information from the distribution of the ejecta.

These official reports mention the levelling of the forests by the storm, but they do not say whether any attempt to use the tree-trunks as anemographs has been or will be made.

The distribution of the volcanic deposits is well shown on Dr. Hector's map. The mud lies in a straight, broad track, the axis of which bears about one point west of north. This should indicate the prevalence of a steady wind from the south or near by.

Yet the people at Rotorua state that the wind there was first from the south-east, and that it then blew with great violence from the south-west. If the south-westerly direction of the wind had prevailed generally, it would have carried the falling mud away to the north-east of the volcano, which it certainly did not do according to Dr. Hector's plan.

It appears to me that the mud distribution is more consistent with the theory of a local indraught, and that the wind direction at Rotorua was a purely local phenomenon.

The sand, again, is distributed over a differently-shaped and a differently-placed area. Instead of having a long band we have an oval. It has fallen far to the eastward of the mud track, and also some miles to the south of the vents. From the latter circumstance it is clear that over this part of the area, during some part of the time, or at some altitude, a wind must have blown from the quarter exactly opposite to that of the wind which spread the mud.

The grey ash is distributed over an oval also, but the oval is a much larger one.

The discrepancies between the tracks of the several dust-clouds and between these and the recorded winds may be susceptible of the following explanation:—It may be that at the earth's surface a broad zone of southerly wind prevailed, within which a small cyclone raged round the volcanoes, like an eddy in a wide river. The main stream may have carried along the heavy mud, and so have preserved to it the straightness of direction which is so marked a feature of its distribution. The dust, which was carried at once into the higher regions, escaped the wetting which made mud of that which remained within the plane of the southerly wind, and being light, because dry, it was easily whirled about to different points by the different winds, or by the gyratory movement which was prevailing above.

The *Argus* reporter has described how a spectator at Rotorua saw a black dust-cloud driving, apparently, dead to windward, and in the teeth of a south-west gale which was then raging at that place. This appearance is what would be expected if the lower winds over a limited area were approaching an inverted vortex, and the upper winds, laden with ash, were sliding outwards and downwards, and distributing their loading all around, after the manner of a gigantic Jupiter.

The last point to which I desire to allude briefly is the relation of the time of the occurrence of this eruption to those periods of maximum frequency of earth disturbances which some physicists have deduced.

It has been noted that in this hemisphere the several periods of earthquake maxima occur in the winter season, in the month of June, during the night time, and between midnight and half-past two a.m.

It is not necessary for me to do more than point out that the Tarawera eruption occurred at ten minutes past two in the night time, during the month of June, and in the winter season.

G. S. GRIFFITHS.

Art. XII.—*Notes on the Area of Intrusive Rocks at Dargo.*

By A. W. Howitt, F.G.S.

(Read 14th October, 1886.)

Introduction.

In a former paper on the geology of the Ensay district* I gave a short section extending westwards from the range on the eastern side of the Tambarra River to Mount Baldhead. If that section had been extended still further to the west it would have shown a tract of lower paleozoic rocks between Mount Baldhead and the range separating the waters of the Wentworth and Dargo rivers; thence an extended tract of intrusive quartz-diorites to a little west of the Mitchell River, and finally Silurian rocks to where, at Castle Hill, they are overlaid at a low angle by Upper Devonian formations. The sketch-section, Plate III., appended to these notes, gives the part between the eastern watershed of the Dargo River and Castle Hill.

A little to the south of the above-mentioned line of section, but parallel with its general course, there is a second outcrop of intrusive granitic rocks, which extend westwards to a point about south of Castle Hill. To the northward of these intrusive areas, which form an almost continuous series from the valley of the Tambo River, there is an unbroken stretch to beyond the Great Dividing Range of the Silurian formations, where the intrusive rock masses again are met with, rising in Mount Buffalo to the height of over 5600 feet above sea-level. To the southward of the line of section referred to the lower paleozoic sediments extend beyond Tabberabera, where they are overlaid by the Upper Devonian rocks, and again reappearing at Boggy Creek, are there seen to have been broken through by enormous masses of porphyritic granitic rocks, the denuded summits of which

* "The Sedimentary, Metamorphic, and Igneous Rocks of Ensay." Royal Society of Victoria. Read November 12th, 1885.

—Mount Alfred, Mount Lookout, and Mount Taylor—are capped by Upper Devonian conglomerates and grits.

These notes refer to part of the Dargo intrusive area. It is divided into two nearly equal parts by the Dargo River, which flows through it in a southerly direction for about six miles. The east and west extent of the area is about twelve miles. It is a comparatively low tract of hills, with smoother outlines than those of the Silurian formations which surround it, and which on the north side rise to a height of over 3000 feet. As in other tracts of similar igneous rocks, the soil is better, and consequently the herbage finer and more fattening than that growing on the surrounding hills. It is to the western part of the Dargo area that these notes especially relate.

Description and Examination of the Rocks.

No fossils have been discovered in the sedimentary rocks of this district, but there can be little doubt that they are of lower paleozoic age, and most likely Lower Silurian. The least altered examples which I have found are at Waterford, where the road to Dargo crosses the Mitchell River, and, as is elsewhere the case with this formation, the beds are alternations of quartzose sandstones, and argillaceous, somewhat slaty beds tilted at high angles. I selected two samples as being typical, and now describe them:—

1. *Argillite.*—This rock is very fine-grained in texture, and of a greyish colour, inclining to a green tint, especially on a cross fracture. It has been affected by slaty cleavage, which coincides nearly with the planes of deposit. It is faintly wrinkled and slightly shining, on the cleavage planes, with spots and strings of hematite, which lie between the latter. With the pocket-lens very numerous but minute scales of a silvery mica can be made out.

Thin slices of this rock under the microscope are found to be composed mainly of a colourless mineral in minute flakes, which are mostly arranged parallel with the cleavage. Since the thin slices of this fragile rock can be only prepared (according to my experience) from cleavage pieces, it follows that the plates of the above-mentioned mineral are parallel to the slice. When rotated between crossed nicols the spaces filled by this mineral, even when several plates are over each other, appear to remain permanently obscured; and even when further examined by the delicate tints of a quartz-plate, I could not detect any apparent change. In this ground-mass are numerous sections of minute crystals of a colourless mica, some of which are clearly foliated, and, being lath-shaped, are sections parallel to the main axis of the crystal. These latter sections polarise with a little colour, and are, I think, referable to an alkali mica, as are also the silvery micaceous scales, which can be made out on the cleavages by the pocket-lens. In addition to these, there are very numerous small granules and irregularly bounded plates of iron ore, which become translucent with yellowish to reddish tints. In places they coalesce into masses, and are then opaque. Some of these are probably hydrated iron ores, but most are referable to the hematite, which can be made out in the hand specimens. Finally, there are numerous scattered dots and larger flakes of an opaque black material—graphite. No grains of quartz are determinable.

In order to gain some information as to these various minerals, I treated the thin slice with concentrated hydrochloric acid, with occasional warming. The only effect observable was the slow solution of the iron ores, the other minerals not being appreciably affected. As the fragile nature of the thin slices did not admit of igniting them upon platinum foil, I had recourse to the less satisfactory proceeding of testing the powdered rock.

A portion of this treated with hot hydrochloric acid for some time was rapidly acted upon, the acid being strongly and characteristically coloured by iron. The solution, examined qualitatively, proved to contain much iron and magnesia and a little potassa. The residue was partly flocculent and partly a blackish powder. The former being got rid of by careful decantation, the latter was dried, and strongly ignited upon platinum foil, and rapidly lost its black colour, and on cooling was of a greyish white. When wetted with a little water I found it to be largely composed of minute scales of a silvery mica. The inference may therefore be drawn that this rock is composed of a magnesian silicate, having a micaceous structure, and apparently optically uniaxial; a mineral resembling muscovite, hematite, and probably also limonite, and finally graphite.

I also made a quantitative analysis of this rock, the results of which I subjoin:—

No. 1.—ARGILLITE.

TiO_2	...	...	...	·49
SiO_2	...	...	...	51·33
Al_2O_3	...	...	...	25·69
Fe_2O_3	...	...	...	4·80
FeO	...	...	...	1·07
CaO	...	...	...	·25
MgO	...	...	...	2·72
K_2O	...	...	...	6·13
Na_2O	...	...	...	·77
H_2O	...	...	...	6·73*
				99·98
Moisture		...	...	1·53
Sp. gr. ...		...	...	2·686

In the absence of more knowledge of the nature of the minerals which form this rock, any attempt to calculate out the percentages would be purely hypothetical, and the constituent minerals are so minute that their isolation seems more than difficult. All that can be said from the examination which I have detailed is that the rock appears to be composed almost altogether of two minerals, one of which is probably a potassa-mica, and the other may belong to the chlorite group. The rock seems to be an example of those paleozoic sediments which, as I mentioned in a former paper, have undergone only the preliminary stage of metamorphism.

2. *Sandstone.*—The second example represents the sandstones of the locality. It is grey in colour, and very much indurated. Traces of the bedding remain where small argillaceous fragments are imbedded in the same plane.

Under the microscope I found a thin slice of this rock to be composed of angular grains of quartz in large amount, angular fragments of felspar, mostly orthoclase, of the character of that found in granitic rocks, others of microcline, finally a few fragments of triclinic felspars, either oligoclase or albite. The interstitial material is plentiful, and has been converted into mica, which is mostly in aggregates of minute scales, but with a few larger flakes, which have all the appearance of muscovite.

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* Including graphite.

This rock is far more altered than the argillite, and strongly resembles some samples of "Grauwacke." The argillaceous paste has been entirely converted into mica, and the rock, as a whole, greatly silicified. The silicification of the sandstones in a greater degree than the argillaceous beds flanking them I have frequently observed. In the metamorphism of the strata which converts their argillaceous paste into definitely crystallised minerals, and especially where mica is the result, silica is eliminated and again redeposited in a crystallised condition, either in the form of strings or veins, or else in the beds themselves as secondary quartz surrounding original crystalline grains in the beds. Under these conditions, it seems to me that the silica has been deposited in the quartzose beds rather than in those which were purely argillaceous. But it must be distinguished between such cases as these and the general silicification which has, in East Gippsland, for example at Jingallala, affected all the strata. I have figured in Plate II., fig. 4, an instance of the silicification of certain quartzose beds, which I have observed at Stringer's Creek, as illustrating my above remarks.

On proceeding from Waterford along the Dargo Road the transition to hornfels rock is complete within about a mile's distance. A similar change occurs in going southwards towards Castleburn, at about the same distance, or a little over. In following up the Mitchell River from Waterford the contact zone of rock is found at no great distance on the west side, and it is therefore evident that the argillites at Waterford are of local occurrence only, and are probably an easterly tongue of the less altered Silurian rocks from the extension of those rocks to the west.

I collected a set of rocks in this district to illustrate various degrees of alteration between the argillites and hornfels. The best series can be found on the road leading from Dargo to Grant.

(1.) This sample represents the argillites of the district, and was collected near Sippery Pinch, about three miles from the contact. It is slightly slaty in structure, and of a yellowish colour, due to infiltration of iron oxide. Under the microscope it is seen to be composed mainly of some chloritic mineral in small flakes, which are mostly twisted, and which, when seen on edge, have the appearance of stout fibres. The whole mass is stained by iron ochre. In the mass are a few flakes both of colourless alkali-mica and of biotite, as well as clastic grains of quartz.

(2.) This sample was obtained somewhat nearer to the contact than sample No. 1. It is grey in colour, and the planes of separation show small spots of slightly different tint, which are still clearer on weathered surfaces. A thin slice is found when examined under the microscope to be made up of a completely felted mass of minute flakes of colourless mica, with rather larger scattered flakes of brown mica. There are also a few scattered flakes of what appears to be graphite. The "spots" are lighter in colour than the rest of the rock, of much the same composition, but with less brown mica and graphite. There are no quartz grains.

(3.) This sample was collected still nearer to the contact, and about midway between it and sample No. 1. Its microscopic appearance resembles that of No. 2, but with a less fine texture. Under the microscope the structure is as in that sample, but the plates of mica are larger.

The next samples, at about a quarter of a mile from the contact, were schistose hornfels. The changes which I have noted are very much those which have been observed and recorded elsewhere in rocks of the same class. There is a gradual and more complete conversion of the argillaceous material of the rocks into mica, and as the hornfels is approached, an increase of silica, together with a final complete recrystallisation of the rock.

The hornfels rocks of this locality differ but little from those which I have described from other places and in former papers. The least altered rocks are those in which the outward general appearance of the sedimentary bed is still retained. In the most altered examples the bedding is almost obliterated, and is only clearly recognisable when the rocks are looked at in mass *in situ*.

A very common type of hornfels is plentiful in Orr's Gully. A close-grained, crystalline, dark blue, or purple, or almost black rock, which in the stream-beds, where the rocks have been laid bare, can be seen to be distinctly bedded. I selected several samples which seemed to me to be most characteristic. The first examined was a highly crystalline rock of a dark greyish black colour, and breaking with an irregular fracture.

In a thin slice I observed it to have a peculiar and beautiful structure, and one which I have also found in other hornfels rocks in parts of the Dargo area. The original structure has been completely obliterated. If it contained any clastic quartz grains in its unaltered state, such are not now recognisable. The ground-mass of the rock is composed of innumerable minute interlocking grains of quartz, which are so arranged that a number of them are so nearly optically the same that they become obscure almost at the same time when rotated between crossed nicols. These areas have in places a rounded or elliptical shape, suggesting that each may represent an original crystallisation afterwards broken into fragments, or perhaps more correctly, separated by irregular flaws. The slice thus appears composed of adjoining dark and light areas, which alternate on rotation. In this quartzose mass are innumerable flakes and rounded plates of two micas, rounded grains and crystals of magnetite, which are all aggregated more in some places than in others.

Subjoined is a quantitative analysis of this rock :—

No. 2.—HORNFELS.

P_2O_5	·15
$Ti.O_2$	·17
$Si.O_2$	62·28
$Al._2O_3$	20·16
$Fe._2O_3$	·53
$Fe.O$	3·84
$Ca.O$	·82
$Mg.O$	2·54
K_2O	6·40
$Na._2O$	1·29
H_2O	1·86
	100·04
Moisture	·72
Sp. gr.	2·744

This sample was selected as apparently representing one of the least originally quartzose sediments. If this is the case, it shows in a marked manner the increase of silica, which I have before referred to, and one may also observe that, as is the case generally in these metamorphic rocks, the amount of combined water is lessened in the process of recrystallisation, together with a total removal of any carbonaceous material.

I found that still greater changes had been brought about in the sediments immediately adjoining the contact. A good example was laid open in a shaft which had been sunk upon a small auriferous quartz vein at the Perseverance mine in Orr's Gully. The contact plane at this place is nearly horizontal, and crosses the shaft about 20 feet from the surface. The beds nearest to the intrusive rock have assumed an extreme form, being almost crystalline granular, and distantly resembling the igneous rocks in appearance. A sample from this place is spotted in places with small oval patches of a yellowish tint, and which, when examined by the lens, have a crystalline-granular structure and a "granitic" appearance, being formed of felspar, mica, and quartz, showing the influence of the adjoining intrusive rocks.

Examined in a thin slice, it proves to be crystalline-granular, and to be composed of—(*a*) Very angular or even cavernous felspars, most of which are orthoclase, the triclinic felspars being both few in number and small in size; (*b*) numerous angular grains and clusters of grains of quartz; (*c*) ragged flakes and crystals of brown mica, which is in parts much bleached in colour, scarcely pleochroic, and having the iron eliminated as crystals of secondary magnetite. This mica is one of the first formed of the minerals, as it is included both in the felspars and in the quartz. (*d*) Very fibrous masses of yellow or colourless alkali mica or aggregations of flakes, or plumose or stellate groups of the same, with a few larger isolated plates. This mica seems to be a late-formed mineral, and may in part be a secondary product of alteration. There is also some magnetite, which may be original.

This sample shows the peculiar metamorphic action upon sediments immediately adjoining the contact, not only in the complete recrystallisation of the materials of the sediment, but also in the generation of felspars, which are not to be found in the hornfels rocks at a distance.

The changes which can be traced out in proceeding from the normal sediments at the outside of the metamorphic zone towards the intrusive rock masses are mainly the conversion of the argillaceous material of the former into mica of two kinds, in the general silicification of the altered rocks, and finally, near to the contact, the complete molecular recrystallisation of the sediments with the production of felspars in those beds which are at touch with the invasive rocks.

It may be inferred that not only has there been an elimination of free silica during the alteration of the sediments, but that there may have been also an accession of it from elsewhere, and also that in the neighbourhood of the intrusive rocks there may have been to some extent an impregnation by them of the metamorphosed beds with portions of their own materials.

In addition to the heat due to the proximity of the plutonic rocks, to the pressure due to the depth below the earth's surface at which this contact action took place, to the action of the mineralised waters included in the sediments, and of the additional water set free during their molecular alteration, account must be taken of the effect of vast mechanical stresses and movements to which the strata bear witness.

The normal strike of the Silurian strata of the district may be taken as about N. 30 degs. to 40 degs. W. At Dargo, for instance at Orr's Creek, I have found the strike of the metamorphosed strata east and west. It is not an isolated case, but occurs in other places—for instance, at Swift's Creek, on a large scale—and it seems probable that this extensive diversion of the strata has been due to the violent forcing of the igneous masses when in a plastic condition into the opening sedimentary beds during elevation of the earth's crust.

THE INTRUSIVE ROCKS.

Aplites.—I have found it necessary to use the word aplite for a certain class of intrusive dykes and veins which I have found in places at or near to the contact, and which are very near in character to certain dykes and masses of igneous rock at Ensay and Omeo, to which I have applied that name. The word aplite is, however, not quite satisfactory if it is restricted to rocks coming under the definition "Muscovite Granites." Although in the cases to which I now refer the generality have muscovite mica in small amount, there are some which have traces also of biotite, or a small amount of biotite only. However, with this proviso I use the term aplite in this paper.*

Where the contacts can be examined, as at Orr's Creek, dykes and veins are found to cross them at various angles. They have all the main characteristics of aplite—namely, that they are crystalline-granular compounds of felspars and

* See Rosenbusch Physiographie der Massigen Gesteine, p. 19; also Die Steiger Schiefer, p. 277.

quartz, with a very small amount of mica, which in most cases appears to be muscovite. In places this alkali-mica is replaced by a brown mica, apparently biotite. Such an example I examined from a vein which crosses the contact near the saddle where the road crosses over to Dargo. A hand specimen is pale buff in tint, fine-grained, and shows small crystalline cleavage planes of felspar and grains of quartz, with very small and rare dark brown flakes of mica.

This general view is borne out by a microscopic examination. The felspars are for the most part orthoclase in irregularly formed crystals, with a few better crystallised plagioclase crystals. A few small flakes of brown mica scattered about among the grains of quartz complete the compound.

The cavernous and broken felspars point to alternations of temperature, affecting the partially crystallised magma, and also to the disturbed conditions under which the dykes were forced into opening but resisting sediments. Another sample which I collected near the same place and examined under the microscope showed me orthoclase felspars, intergrown with quartz, after the "graphic" manner of structure. There were also triclinic felspars, much eroded externally. Grains of quartz filled in the interspaces, and a few small flakes of brown mica completed in this instance also the compound.

In this rock the signs of violence are also clearly to be made out. The felspars have been much broken, and the fragments can be seen jammed into interspaces, thus showing that the rock had been in movement shortly before it had completely consolidated.

A third example from a dyke-like vein in Orr's Gully is a light-coloured and crystalline-granular rock, in which numerous shining cleavage planes of felspar can be seen; with quartz, and very minute and rare plates of black mica.

As seen under the microscope, it is composed of orthoclase felspars, in angular or cavernous crystals, which are rather larger relatively, as well as more broken and eroded, than the fewer triclinic felspars which accompany them. Some crystals of microcline also are to be seen. The quartz is in considerable amount. The mica, which is very sparsely scattered through the mass, is brown and fibrous, and only slightly pleochroic.

Of this sample I carried out a quantitative analysis, the results of which follow:—

No. 3.—Aplite.

$Si.O_2$	76·48
$Al._2O_3$	13·94
$Fe._2O_3$	tr.
Ca.O	1·08
Mg.O	·01
H O	4·90
$Na._2O$	3·70
H_2O	·86
	100·97
Moisture	·15
Sp. gr.	2·611

Disregarding a small amount of kaolin and of magnesia-mica, the above analysis calculates out satisfactorily for a rock composed of orthoclase, felspar, oligoclase, and quartz. The oligoclase is of the composition of ab. 6, an. 1, and therefore very near to the border of the group nearest to albite.* The orthoclase, oligoclase, and quartz are in almost equal molecular proportions.

Besides these dykes, which are characteristic of the contacts, there are also numerous other dykes, many of which traverse the intrusive masses, and perhaps more frequently than the adjoining schists. It is, however, possible that this may be more in appearance than in reality, owing to such dykes being more easily seen in the former than in the latter country.

I selected three samples of dykes as being typical of those which I had met with.

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* There is some little difference in the views expressed by authorities as to the limits of the albite and oligoclase groups, as will be seen from the following particulars, extracted from works at hand :—

	Albite.	*Oligoclase.*
Rosenbusch ...	Ab 1 an 0 to ab 8 an 1 ...	Ab 6 an 1 to ab 2 an 1
Tschermak ...	Ab ...	Ab to ab 3 an 1
Lapparent ...	Ab ...	Ab 3 an 1
Des Cloizeaux	1re classe	Ab 3 an 1 to ab 5 an 1
	2de classe	Ab 4 an 1 to ab 2 an 1
	3me classe	ab 2 an 1

Rosenbusch—Physiographie, &c., 2nd edition, Vol. I., p. 521.
Tschermak—Mineralogie, 2nd edition, p. 465.
Lapparent—Cours de Mineralogie, 1884, p. 350.
Des Cloizeaux, Oligoclase and Andesine, Tours, p. 9.

(1.) This sample was taken from a strong dyke which traverses the quartz diorites on the eastern side of the Dargo River, and it lies as rough masses on the hill-sides, where it crops out. It is compact, and of a greenish colour, weathering to a lighter tint. It has a slightly glassy lustre on a fresh fracture. Under the microscope the ground-mass contains a considerable amount of colourless basis, the remainder being innumerable minute acicular crystals of amphibole, some with ragged ends, and of all sizes, between ·008-inch and ·001-inch in length, and ·0005-inch and ·0001-inch in breadth.

These crystals lie at all angles across each other in the basis, and are slightly pleochroic. In this ground-mass there are clear and colourless simple crystals of orthoclase. This rock, therefore, is a variety of Syenite.

(2.) This dyke crosses the gap between Waterford and Dargo. It weathers into rough, reddish-coloured blocks. It is of a rather fine grain, and inclined to purple in tint on a fresh fracture. Rather numerous small prisms of black hornblende can be observed. In a thin slice I found this rock to have a ground-mass in places of a granophyric structure, but the porphyritic minerals of the rock do not in all cases form the centre of the granophyric masses. These are formed by radially concentric colourless prisms of quartz, which in places include crystals of the other minerals which form the rock. The remainder of the ground-mass contains much colourless basis throughout, in places amounting to rather large patches.

In this ground-mass are eroded crystals of dark reddish brown mica, which are pleochroic in shades of dark reddish brown and yellow. There are also numerous rather lengthened prisms of amphibole, which in cross sections show the characteristic cleavage of that mineral. The absorption is rather strong, and the colours of the rays are in shades dark chestnut brown, light chestnut red, and yellow.

(3.) This dyke crosses the quartz diorites at Orr's Creek, and is of a somewhat peculiar character.

It is black in colour, weathering to greyish-black. In fresh fractures one can observe numerous small shining flakes of pinchbeck to black coloured mica, with pyroxene and some larger isolated felspars. Owing to the extremely dark tint of the ground-mass of this rock, it is most difficult to prepare a thin slice in a satisfactory manner. The ground-mass is partly a very dark-brown basis and partly of exceedingly numerous microliths, being minute, stout, and often twisted fibres or grains, the result of devitrification. These are collected together much more in some places than in others. In this ground-mass are:—

(*a.*) Magnetite, in rounded crystals and grains.

(*b.*) Colourless prisms and crystalline grains of augite. These are not only porphyritic, but also descend in size to almost microscopic dimensions in the ground-mass. In places the augite is in clusters of angular grains, which seem to be the crushed remains of crystals. These clusters of grains are enveloped in the mica next to be mentioned.

(*c.*) Dark brown red mica, in which the absorption is strong, the rays being orange-red, and almost colourless.

(*d.*) Serpentinous pseudomorphs, after olivine. In some of them the form of the original mineral is still preserved, together with the meshed appearance produced by the fractures which characterise it.

(*e.*) There are also a few crystals of felspar, which are not striated, but which have not the form, and do not obscure after the manner of orthoclase.

This rock consists essentially of a ground-mass, containing some basis, and having porphyritic crystals of augite and mica in about equal amounts; the olivine about half the amount of either, and the felspar quite subordinate.

The peculiar features of this rock, and the occurrence of the colourless augite, together with the olivine pseudomorphs, lead me to think that the rock is pretertiary in age, and, according to the classification I follow in these notes, a very basic variety of Diabase (Olivine-diabase).

Quartz Diorites.—So far as I have examined them, the massive intrusive rocks of Dargo belong to the diorite group. Most commonly they are light in colour, but in places the mica or the amphibole, or both, increase so much that the rock necessarily has a darker shade of colour than in those examples, in which the felspar and the quartz are more abundant. In almost all cases the rock is a quartz diorite, but I have met with places where the quartz almost, if not quite, disappears. Such rocks are found in parts of Orr's Creek, and a sample, to which I shall refer later on, was collected near where the sketch section on Plate III. crosses it.

As in other parts of Gippsland, these diorite rocks weather much more rapidly than the surrounding sediments, and, as a consequence, the Dargo area forms an extensive basin of hills, which are low and rounded as compared with the towering Silurian mountains which surround them. But wherever within this area traces of the zone of contact rocks still remain undenuded, the hills are rough and rugged. The vegetation also invariably tells the observer the character of the rocks, for the diorites decompose into a soil of better quality, clothed with more nutritious grasses, and the forests are less dense, and are of different eucalypts than on the Silurian formation.

The sample which I selected for examination from the varieties of diorites is of the more basic kind. The other samples strongly resemble similar rocks which I have described from Noyang and Ensay.

The rock under examination is a crystalline-granular compound of medium texture, in which by the pocket-lens plagioclase felspars, dark green to almost black hornblende, traces of black mica, and very little quartz can be made out. The rock is somewhat darker in colour than the generality of the diorites of this neighbourhood. When examined under the microscope it proves to be composed of the following minerals:—

(*a.*) A little magnetite, in somewhat larger crystals than are usually found in these rocks.

(*b.*) Amphibole, in very cavernous crystals. Some are twinned in the usual manner, and I measured obscuration angles up to 20 deg. Pleochroism is not strong in shades of brown. The mineral has become fibrous, and is also much chloritised. In places small clusters of talc-plates have also resulted from alteration.

(*c.*) Triclinic felspars, which predominate in amount somewhat over the amphibole. Some of the felspars are broken and crushed, as, indeed, are some crystals of amphibole. The felspars are more or less kaolinised, but in an inequal manner. The size of the felspars crystals differs, some being large and very compound, and having somewhat the appearance of oligoclase. Others are smaller and more simple. The latter are better developed than the former. These differences suggest two generations of felspars.

In the slices which I prepared there were but few sections of these felspars in which reliable measurements of the obscuration angle could be obtained, and these were all in the plane OP— $\infty\bar{P}\infty$. The values thus obtained were from 3 degs. to 23 degs., thus suggesting a soda-lime felspar on the border between Andesine and Labrador. This, however, assumes that the measurement of 3 degs. was taken in the plane OP (001); a less angle would still be in the Andesine group, unless it were less than 1 deg.* It also assumes that only one kind of plagioclase occurs in this rock, which is not at all certain.

(*d.*) A very small amount of quartz, in homogeneous portions, filling spaces between the minerals, otherwise resembling that of the granitic rocks.

The subjoined quantitative analysis is of this rock. No mica was observable in these slices:—

No. 4.—Quartz Diorite.

$Si.O_2$	...	...	...	52·03
$Al._2O_3$	...	...	...	20·57
$Fe._2O_3$	...	...	...	1·60
Fe.O	...	...	...	6.97
Ca.O	...	...	...	7·80
Mg.O	...	...	..	5·39
K_2O	...	...	...	1·34
$Na._2O$	...	...	...	2·37
H_2O	...	...	...	1·27
				99·34
Moisture		...	...	·26
Sp. gr....		...	...	2·855

In order to be able to calculate with some degree of precision the percentages of the rock-forming minerals from this analysis, it would be necessary to have a knowledge of the composition of the amphibole and of the felspars. An estimate of the probable composition of the rock can, however, be made by calculating the felspars out on the basis of the optical measurements, and also the alteration products in the assumption that the H_2O indicates kaolin and chlorite, which, according to the microscopic examination, would probably be in the proportion of one of the former to

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*	Formula.	Obscuration angl on O.P. (001).
Oligoclase	Ab 2 an 1	3° 35′
Andesine	Ab 3 an 2	2° 12′
Andesine	Ab 4 an 3	2° 58′
Labrador	Ab 1 an 1	5° 10′

Rosenbusch—Physiographie, &c., 2nd E., p. 535.

three of the latter. The remaining molecular proportions should then give the amphibole, with a small remainder of silica representing the free quartz. In this calculation the small amount of Fe_2O_3 is regarded as indicating the magnetite, and the minute amount of talc is disregarded. The ratio between the remaining components which are thus assigned to amphibole are such as to fall within the limits given by Rammelsberg for an aluminous hornblende, being Al_2 to $\overset{\shortparallel}{R}$ as 1· to 3·, and $\overset{\shortparallel}{R}$ to Si as 1·5 to 1·* Taken in percentages, the rock may accordingly be composed as follows:—

Magnetite	2·34
Kaolin	5·69
Chlorite	9·72
Andesine	36·55
Hornblende	33·55
Quartz	12·15
	100·00

Auriferous Veins in the Dargo Area.

Gold-mining has been carried on for many years in various parts of the intrusive areas referred to in these notes. Alluvial gold in payable amount has been found at Dargo, Tucker Creek, Granite Creek, and other places, and in less amount is almost everywhere to be met with in the gravel of the streams. The alluvial gold is either in small laminated flakes or in ragged pieces, according as it is found in the larger streams, or in localities near to the veins from which it has been set free. In a number of places small gold-bearing quartz veins have been discovered, and at Tucker Creek, Budgee Budgee, and Orr's Creek such have been more or less worked.

At Orr's Creek, to which place these notes especially refer, a number of small quartz veins have been worked for several years back in the hornfels rocks immediately adjoining the contact with quartz diorites. This mine is called the "Exhibition," and I now give some particulars concerning it, which are of interest, as showing the character of the small quartz lodes and veins, the wearing down of which has set free the alluvial gold of the district.

* Mineralchemie, page 418.

The Exhibition mine has been opened out at about half a mile south of the road leading from Waterford to Dargo, and not far from the low saddle on the divide between the Mitchell and Dargo waters. It is on the contact of the quartz diorites with the sediments which are there metamorphosed into hornfels. The angle of dip of the hornfels beds at the mine varies within short distances on a nearly east and west strike. I found, in examining the workings of this mine, that the gold is in very narrow veins of mineralised quartz not exceeding six inches in width, and in some cases being hardly more than a quartz lining to the partings of the rock. The veins fill narrow fissures passing up through the metamorphosed sediments from the contact plane, and, so far as I could observe, not passing down below it into the plutonic rocks. The gold is in small particles, some being so minute as to resemble "gilding." It is not confined to the veins of quartz, but is occasionally found in the hornfels rock in places where that rock is very silicious. Together with the gold are ordinary iron pyrites and galena. There are a number of thesevery narrow veins within certain limits of about three feet wide, thus defining what in miners' language may be termed the "lode country." At one time it was attempted to work and crush the whole of this width for the sake of the gold contained in the narrow veins and small strings of quartz in the hornfels, but the extreme hardness of the rock and the comparatively small amount of gold caused the attempt to be given up.

In Plate I. I have given a horizontal section of the mine as I saw it in 1883 in the middle adit, and on the same plate a set of four cross sections of the lode. These will explain better than words some of the features of this mine. Since the time of my visit the mine has been worked from time to time when water was available, with results to which I will now refer. For most of the facts outside of my own knowledge I am indebted to the courtesy of Mr. J. B. Kelly, J.P., of Dargo, who, as mining registrar, and also as a shareholder in the Exhibition Company, has had opportunity of knowing the whole course of the mining operations from the first. To Mr. Stellwag, of Sale, the legal manager of the company, I have also to express my obligations for freely giving me the information in his possession.

The Exhibition mine was discovered by the brothers Jorgensen, who are known as enterprising prospectors. To work it the Exhibition Gold-mining Company (No Liability) was formed, in which the prospectors held one-half of the shares, the remainder being held by two shareholders in Sale, with the exception of a few shares held at Dargo and Bairnsdale. A steam-engine, working a battery of eight stampers, was erected at the mine, which was managed for the company by one of the shareholders (Mr. H. Jorgensen). The gold obtained, of which I subjoin a tabulated return, was from the stone only, and not from the pyrites, which has not been separated from the tailings or treated in any manner. The company is still constituted as above-mentioned, and up to the end of May, 1886, had produced an amount of gold equal in value to the total cost of machinery and labour. The mine and machinery are at this time let on tribute.

Year.	Number of Tons of Quartz Crushed.	Total Yield.
		oz. dwt. gr.
1881	145	142 0 0
1882	364	258 13 10
1883	201	196 5 5
1884 to June 9, 1886	481	417 14 0
1881 to June 9, 1886	1,191	1014 12 15

The yield of gold varied from 9 dwts. 19 grs. to 1 oz. 6 dwts. per ton of quartz.

The interest attaching to this mine is due to the evidence it affords that such narrow auriferous veins as those at Orr's Creek may, with careful management, even be capable of yielding a profit. To this subject I shall refer again later on. Mr. Kelly informs me that the gold from the Exhibition mine was worth £4 per oz., which would agree nearly with a composition of Au. 94·20, Ag. 5·80. This proportion is higher, as to the gold, than I should have expected in the Dargo area. Some years ago I examined a series of samples of alluvial gold from different geological formations in Gippsland and at Omeo, with the result that I found the composition in Silurian areas to lie between the proportions of silver alloy to gold of 1:12 and 1:40, and in areas of metamorphic or plutonic rocks of 1:2·2 and 1:9.*

* A number of these determinations were recorded in Reports of Progress, II., p. 69, and III., p. 238, Geological Survey of Victoria.

This difference in composition in gold from the two classes of areas can be seen in two assays which I now give, in addition to the former, for the purpose of illustration. A is alluvial gold from the Silurian formation at Crooked River, and B alluvial gold from the metamorphic area of Dargo.

	A		B
Au.	96·923	...	82·969
Ag.	2·564	...	16·055
Oxydisable Metals and loss	·492	...	·917
	99·979		99·941

The connection which I have here noted between the geological formation and the amount of alloy with the gold seems not to be confined to the districts I have referred to.

An examination of the reports of mining surveyors shows reason for suspecting that there is a similar connection between the geological formation and the composition of the gold found in it throughout Victoria.* But it is not so clearly to be made out, because the highest and lowest price paid for gold in any locality is not always necessarily for gold raised there, but also includes gold brought from other places.

The subject is an interesting one, and capable of throwing light upon the source of the gold, and also upon the processes which have been at work in depositing it in the quartz reefs. But it would require much labour to work it out in a satisfactory manner. Examinations would have to be made both of reef and alluvial gold from the same locality, and of reef gold from different parts and depths in the same mine. This should be repeated in many places and in different formations. In connection with such a series of examinations there should be also another of the local rocks, and also of rocks taken from different depths and places in the several mines from which the gold had been collected for examination.

The comparison of such gold assays, and of the microscopical and chemical examinations of the rocks, would, in all probability, lead to some conclusions as to whether the

* Reports of the Mining Surveyors. Published by the Department of Mines. "Table showing the lowest and highest prices paid for gold." Years 1880 to 1885.

gold has had its source in the Silurian, metamorphic, or igneous rocks, or in connection with them.*

In two other places not far from Dargo other similar contact reefs have been opened and partly worked, one at Granite Creek, at the extreme western end of the series of intrusive areas, and the other at the extreme eastern end, at Tucker Creek.

A few words about them will be of use in truly estimating the evidence given by the Exhibition mine. The Budgee Budgee mine at Granite Creek in so far resembles the Exhibition mine that it is at the contact of the quartz diorites, with presumably Silurian sediments. But the contact plane has been denuded, and the quartz lode is found in the plutonic rock. The strike of the lode is east and west, dipping from 40 degs. to 50 degs. to the north. When I visited the mine while it was being worked, several years ago, I found a tunnel driven in the western side of Granite Creek, on the course of the lode. The quartz vein being worked was from 6 to 9 inches wide; but it only formed part of the lode, which I found to be nearly 3 feet between the walls. I have given a diagram of the lode as I then saw it at the face of the tunnel in fig. 2, Plate II.

An incorporated company was formed to work this mine. Machinery was erected of a kind not adapted to the nature of the stone to be operated on. A good deal of work was done, with little result, and finally the company was wound up, and the mine abandoned. At the present time the mine has been re-occupied by a party of working miners.

The standard of the gold at this place is somewhat low, and falls in near to that obtaining in other igneous or metamorphic areas in Gippsland. According to information obligingly communicated to me by Mr. Horace Rich, of Sale, a former shareholder in the Budgee Budgee Company, the gold from that mine was worth £3 17s. A sample of alluvial gold which I examined from Granite Creek, close to this mine, I found to be composed of 90·05 per cent. of gold, and 9·95 per cent. of silver.

At the sources of Tucker Creek, a small stream which flows into the Wentworth River, there are a number of quartz veins at the contact of the quartz diorites and paleo-

* Henwood makes the remark in "Observations on Metalliferous Deposits" (Transactions of R. G. S. of Cornwall, Vol. VIII., p. 359) that in Brazil "detrital gold . . . is always of better quality than mine gold of the neighbourhood."

zoic sediments. In Plate II., fig. 1, I have given a diagram of one of these veins, where it had been laid open by a shaft close to the contact. When these quartz veins were discovered to be much mineralised, and to contain some gold, a "no liability company" was formed to work them. A shaft was sunk, and a tunnel was driven along the course of one of the larger reefs. Trial crushings were taken out at three different places, and tested at the Good Hope battery at Grant, with a yield of 11 dwts. to the ton; at the Normanby battery, yielding 8 dwts. to the ton; and the third at the Budgee Budgee mine, giving a return of 15 dwts. to the ton of stone. Finally a favourable report was made as to the prospects of the mine by an expert, and upon this a steam-engine, driving a battery of ten stampers, was erected, and a considerable amount of preliminary work was done. Hereupon a crushing was had from the mine, with the result, according to some statements, of 1 dwt. per ton, and, according to others, of nothing at all. The whole enterprise was now dropped, the company was wound up, and the battery was sold and removed elsewhere, after an expenditure of about £2500. It is not proved, however, that these reefs at Eureka are so absolutely valueless as has been assumed They are highly mineralised, and the appliances were probably—as was the case elsewhere in the district—not adapted to the treatment of such stone. Moreover, the trial crushings, if *bona fide*, show that some of the veins were auriferous, although not in a great degree, yet far more so than the one crushing made at the Eureka battery would indicate.

The ill-success which in the past has attended attempts to work such reefs as those at Dargo and its neighbourhood makes it desirable to trace out the causes of failure, and also to ascertain whether it might not be possible, in the future, to work them remuneratively. Conclusions arrived at by considering these cases will also apply to other similar auriferous reefs in Gippsland.

It is well to say that the experience of the past, taken as a whole, has been unfavourable. In no single instance with which I am acquainted have such reefs as these been worked at a profit by incorporated companies. The Exhibition mine is not an exception, for no profit has been made, and the return to the shareholders of their expenditure on machinery and labour is due, as I see it, to the fact that the mine has been managed and worked in the greatest part by the shareholders themselves, who had a direct interest in economy of working. It has not been the result of richer stone, or more of it, for the quartz veins in this mine are exceptionally narrow, and contained little, if anything, over the ordinary yield of gold in other similar mines. It has been due to careful and economical working, and the shareholders have contended, with some success, against difficulties under which other mines have succumbed.

Some of the difficulties in the way of working this mine at a profit have been, in addition to the narrowness of the quartz veins, the hardness of the country containing them, thus making the cost of raising stone for crushing out of proportion to the yield of gold. The crushing plant was not adapted to the separation and saving of the gold from the ores accompanying it. Moreover, so far as I am aware, there was not sufficient check kept upon a possible loss of gold through the injurious action of those minerals upon amalgamation; in other words, it was not known how much gold was lost through this cause or with the pyrites, which were not saved. The want of water at times also caused loss of time through stoppage of work and delay.

As against these drawbacks, the company was a small one. The mine was managed, and partly worked, by the shareholders, which favoured economy.

The inference is justified from these statements that, had the gold-bearing veins not been so exceptionally narrow, the hornfels containing them not so hard to work, the appliances for treating the stone properly adapted to the character of the minerals with which it was impregnated, there would probably have been some profit beyond the return of the capital invested.

It seems, from a comparison of the examples of the Exhibition, Budgee Budgee, and Eureka mines, that such reefs may be made remunerative when worked with appropriate appliances and with judgment and economy. The probability is that they could in many cases be made to pay if worked by small companies of a co-operative character, although perhaps incorporated for individual security. But the working expenses would require to be kept well in hand, the crushing plant to be effective, and at the same time adapted, for the highly mineralised stone of the contact reefs, and also so constructed as to admit of being readily transported elsewhere should the mine fail. The saving and treatment of the pyrites would require more attention than has hitherto been given to it, for in general nothing was done with the tailings except to facilitate their departure from the mill, and no care was taken to learn whether any gold was being carried away in them or not.

In some instances in past years I have obtained samples of pyrites from such mines in the district, which in all cases proved to be auriferous, up to over in one case 70 oz. to the ton of pyrites.

The want of success in the working of the contact reefs by incorporated companies in the past is brought well into view by comparison with the individual efforts of Mr. Peter Forsyth, an enterprising quartz miner, at Swift's Creek, who for some years past has perseveringly worked on his own account with satisfactory results on one or other of the contact reefs of that district. At the Budgee Budgee Reef the Messrs. Hardy and other miners are now working with prospects of ultimate success.

It seems probable to me that the auriferous contact reefs of Dargo, Swift's Creek, and Omeo will in the future be worked somewhat in the manner now indicated, and with remuneration to those engaged upon them. This would be a true revival of one branch of quartz-mining. It would not afford a field of operation for the promoter of companies, but it would give remunerative employment to men who wished to work on their own account, and who would be content with doing so in an unpretending manner, for moderate returns on the capital invested.

There is one question which I have not yet considered, namely, the probable origin of such reefs as those of Dargo.

Such quartz veins are found either in the intrusive plutonic rocks where laid bare by denudation, in the contact between them and Silurian sediments, or in the latter, where either metamorphosed into hornfels, or at a greater distance from the contact in a more normal condition. It is safe to assume that the quartz veins in the plutonic rocks once extended upwards into the sediments whose denudation has supplied the streams with the alluvial gold, and that those now found in the contact zone would, if traced to sufficient depths, pass into the intrusive rocks. Such veins fill fissures whose original width may have depended upon downthrow or upon a side shift which brought discordant parts of the walls together, and thus prevented the complete closing of the fissure. Narrow and regular veins, such as those at the Exhibition mine, indicate probably fissuring through homogeneous rocks, or without shifting of the sides of the fissure. As I have before said, the lodes which fill these fissures do not, as a rule, extend any distance down into the intrusive rock masses, but thin out, and are lost. The fissures were clearly formed at that time when the sedimentary crust was raised, and its strata opened and faulted during the time of the plutonic activity to which I have so frequently had occasion to refer in this series of papers. This took place probably at the close of the Silurian age; but it does not follow that these fissures were then filled with the quartz lodes and the minerals which we now find in them; nor can it be assumed that the fissures were opened once only; on the contrary, I think that, as to the veins at the Exhibition mine, they have been probably opened and widened by a second addition of quartz. I have observed places where the quartz was divided by seams carrying ores parallel to the walls of the lode, and a sample which I sliced and examined under the microscope confirmed this belief. I found the quartz to be crystallised, and that one growth of crystals started from the walls, being filled in by a confused mass of imperfect crystals in the centre. It must, however, be remembered in connection with this subject that fissuring of the rocks forming the contact zone would probably follow any of the great changes to which the plutonic masses, together with the adjoining sediments would be subjected, through cooling down of the former or general subsidence of the crust. The periods of time during which all the changes took place, from the invasion of the sediments until the cessation of plutonic activity in that area, were evidently geological periods, and not to be measured in years.

The fissures at the Exhibition mine are narrow, and the lodes do not include, as is the case elsewhere, fragments of the bounding rocks which have fallen in during the movements of the rocks, and thus become highly mineralised during the lode formation.

The gold in these contact lodes is almost invariably associated with large amounts of ores, such as arsenical and ordinary pyrites, copper pyrites, galena, and, more rarely, blende. Near the surface these ores become decomposed, and the honeycombed quartz which remains retains the gold, which was formerly included in the sulphides and arsenides in its cavities, or embedded in hydrated ores. The greater part of the ores and the gold are found within the walls of the lode, but it is very commonly the case that the rocks at each side are also not only much altered mineralogically, but also more or less impregnated with ores. The mineral alterations in the walls of the lode are more recognisable where the lode passes down into the plutonic rocks than where it is in contact schists. As an example of such alterations, I may quote the Eureka mine at Swift's Creek, where the reef passes through massive quartz mica diorites. I observed that the foot-wall of the lode was much lighter in colour than the hanging wall, as well as being impregnated with ordinary pyrites. A hand sample of the rock is crystalline-granular, and greenish yellow in tint. In a thin slice it can be seen that the felspars have been so much altered that no traces of any twinning remain, the crystals being either entirely kaolinised, or where less altered, having the appearance of one of the pinite minerals. Traces of the former presence of iron-magnesia mica remain as fibres of chlorite, and the quartz is of two kinds—namely, the crystalline grains of the original rock and a second generation of much smaller and very interlocking granules.

In some cases I have observed, in addition to such mineral alterations, that minerals in the walls of the lode have been structurally altered by crushing.

The extensive impregnation of this class of quartz lodes with various kinds of ores, the banded structure of some of the quartz veins, and the frequent restriction of the gold to some of the bands rather than to the others, the impregnation of the walls of the fissures with ores, and the extensive mineral alterations which have been made in the bounding rocks, all point, when taken together, to the formation of this class of contact veins by the action of aqueous solutions charged with mineral and metallic materials. It is probable that these solutions were heated, although not necessarily to any high temperature, for the observations made by Daubrée on the effects produced by the thermal waters at Plombières on the Roman masonry, and metallic objects therewith, show that a comparatively low temperature will suffice, even at the earth's surface, to bring about mineral alteration and the formation of ores.*

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* Memoire sur la relation des sources thermales de Plombières, &c. Annales des Mines, 1858, XIII., p. 227. Etudes et experiences synthétiques sur la Metamorphism, Mémoires présentés a l'Académie des Sciences, XVII., p. 98.

It may be well at this place to draw a distinction between the auriferous quartz veins and other veins of quartz which are found at or near the contacts, and which have, in three instances within my knowledge in Gippsland, been fruitlessly prospected for gold.

The class of quartz veins to which I now refer is not, so far as I have observed, auriferous, or even ore-bearing. At any rate, no gold has been found in them by any of the ordinary methods of examination.* They are either of quartz only or of quartz together with one or more characteristic minerals. In the neighbourhood of Dargo I have observed quartz veins of small size of this kind near or at the contacts composed of quartz with small schorl crystals. Far more clearly, however, is the distinction between the two classes of quartz veins to be seen near Omeo. The auriferous reefs which have been found and partly worked there are essentially of the character of those at Dargo, being veins of quartz mineralised by arsenical and ordinary pyrites and galena with gold, at the contact of quartz mica diorites with the regionally-metamorphosed schists. The features which I desire to bring out into view are there much more marked than at Dargo, and I therefore take my illustrations from them. Besides these auriferous quartz lodes, there are also throughout the neighbourhood of Omeo numerous veins, and even large masses of quartz, which fill fissures in or are interfoliated with the metamorphic schists, or traverse parts of the plutonic rocks. The quartz of these veins is in places milky in colour, and in others translucent and extremely crystalline. In addition to these veins of quartz only there are others of the same class which contain schorl or cleavable masses of felspar, or muscovite mica, or two or all of them together in varying proportions, so that veins may be extremely quartzose with but little proportion of minerals, or may be so charged with them as to become a variety of pegmatite.

A study of the veins composed of quartz alone, or of quartz with schorl, brings out certain features which are of moment in this consideration. The prismatic crystals of schorl are often penetrated by thin films of quartz, or have been broken across, the parts being removed from each other and separated by the silica. If such crystals are extracted, it is found that the quartz has perfectly moulded their most

* I now refer only to the Dargo and Omeo districts.

minute markings, and that, moreover, this moulding was completed after the crystals were formed. The fractures of the schorl crystals, the removal of the parts from each other, the penetration of films of quartz into small fissures in the crystals suggest that the silica, when this happened, was, as a whole, capable of some movement under a degree of pressure, and the moulding of the quartz to the schorl crystals shows that it was plastic. The supposition that the quartz may have been gradually deposited from solution round the crystals of schorl until the fissure was completely filled seems to be quite negatived by the observation that the schorl is not attached to the walls of the fissure, but "floats" free in the quartz. This requires, therefore, that the quartz should have been in such a state as would admit of movement, and yet in a condition far denser than that of an ordinary solution. These observations on the mode of occurrence of crystals of schorl in quartz veins are not new, but have been made and recorded long ago.* I now mention the particulars, as I have seen them at Omeo, as being necessary to the explanation which I desire to offer.

It seems to me that the above facts admit of only two alternative explanations. Either the quartz was in a molten condition when it filled the fissure, or it was in the condition of a solution in an extreme state of condensation. There is no evidence whatever in the adjoining rocks of any such elevation of temperature as would be necessary for the fusion of quartz, nor do I think that at the present day geologists would be inclined to admit an hypothesis based thereupon.† There remains, then, the second hypothesis, and this would be satisfied by the supposition that the quartz had been forced into the fissure in a colloidal condition, accompanied by such plutonic emanations as would suffice, together with small amounts of bases contained in the colloid silica to the formation of schorl.

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* For instance, see Bischoff, "Lehrbuch der Chemischen, und Physicalischen Geologie," Band II., 552.

† I observe some remarks by Professor Rosenbusch, which have a bearing upon this question. He says ("Microskopische Physiographie der Petrographisch wichtigen Mineralien"—2nd Edition, p. 344):—"Eine darstellung des quartzes aus schmelzflüssigen silikat-mutterlaugen ist bis darhin stets vergeblich versucht worden. Der Grund dürfte darin zusuchen sein, dass die künstlichen Silikat-schmelzen nicht wasserhaltig hergestellt werden können, wie es die natürlichen sind."

The occurrence of such quartz veins at the contacts and in the schists adjoining, as well as in the plutonic rocks, suggests the source of the silica.

It seems that in plutonic rocks, such as the quartz diorites of Dargo and Omeo, the most basic of the constituent minerals have been the first to crystallise out of the magma in definite forms, thus leaving it more silicious after each successive crystallisation. The gradually increasing acidity of such a magma may be inferred from the observations which I have recorded on the quartz diorites of Noyang,* where the successive intrusive rocks are increasingly silicious, and the latest of them are dykes composed of quartz and felspar only. The study of the Noyang rocks shows also that which has been abundantly proved elsewhere—namely, that the quartz consolidated from a plastic condition, which was almost certainly that of a colloid containing a certain but relatively small proportion of alkaline water, some of which can still be found in the minute fluid cavities, which in places fairly swarm in the now crystallised quartz. In these cases the silica was the last constituent to crystallise, and it moulded itself to the forms of the other minerals, and filled in their interspaces just as the quartz filled in the vein fissures, and moulded the schorl prisms in the case of the quartz veins in question.

It seems to me, therefore, more than probable that such quartz veins as these represent some of the residual silica of the plutonic magma, after the compound minerals had crystallised out, and that this residuum was squeezed out while in a colloid state into every adjoining fissure and plane of separation. No high temperature would, on this view, be necessary to produce these dyke-like quartz veins, for the exudation of the still colloidal silica was brought about by the reduction of temperature, which caused the plutonic magma to solidify.

On the strength of these grounds, I conclude that the quartz veins, which I desire to distinguish from those which are auriferous, solidified from the residual colloidal silica of the plutonic masses.

It may be said with great truth that these quartz veins are of plutonic origin, for they differ but little, except in

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* "The Rocks of Noyang." Transactions Royal Society of Victoria, Vol. XX., p. 18.

bulk or in the final conditions of their crystallisation, from the silica of the holocrystalline rocks.*

I may sum up my remarks by saying that these plutonic quartz veins were formed at the cessation of the invasion of the sediments by the great igneous masses, and when these latter were crystallising and the temperature had begun to lower. They have not produced mineral changes in the rocks containing them, nor are they ore-bearing.

The auriferous quartz veins of the kind found at Dargo were formed at a later time, when the temperature had fallen still more, and when the cooling solutions deposited their mineral or metallic burdens in the fissures they permeated, or were precipitated by other solutions percolating from the bounding rocks or from above. When these auriferous veins occur in the plutonic rocks, the "country" bounding the fissure is generally found to have been much altered, and to be also more or less charged with the same ores that enrich the lode. In these cases the fissuring and formation of the lode is clearly subsequent to the consolidation of the rocks.

Although the interval between these formative processes, that of the plutonic and auriferous quartz veins, was no doubt vast, for the cooling of the plutonic rocks and of the heated sediments must have extended over what we should call ages of time, yet both were parts of the same great sequence of events which commenced towards the close of the Silurian age, and extended far into the Devonian period before it terminated.

Conclusion.

I have found it always advantageous to summarise the conclusions to which the study of any subject has led. By so doing a clearer view of the field of inquiry is gained, the connection of the various observed facts becomes more apparent, relations show themselves which were not before seen, and it not infrequently happens that it is possible to frame a tentative hypothesis explaining the observed facts,

* I have been gratified to find that these views, to which the study of metamorphism in the Gippsland Alps has led me, are substantially those which Professor Lehmann has recorded in his magnificent work on the origin of the crystalline schists. Among other passages which are worth the most serious consideration by geologists, I note his remarks on the subject of those quartz veins which I venture to term "plutonic." See p. 56—Die Entstehung der Altkrystallinische Schiefergesteine—Bonn—1884.

and serving as a test for the value of the work done. I propose, therefore, now to summarise the main results at which I consider myself to have arrived, and I shall also venture to suggest what seems to me, on broad lines, to be a possible explanation of the origin and formation of the auriferous quartz reefs of the district in question.

The quartz diorites of Dargo are evidently part of the masses of plutonic rocks which underlie all Gippsland, and which, by denudation, show at the surface in very many places, and at all elevations, from the sea-level up to the highest mountain tops. The Dargo area is one of a connected series which extend in the lower paleozoic formations for nearly fifty miles from the Tambo River, and then, if the same conditions continue, are covered from sight by the Upper Devonian rocks of the Avon River drainage area. The general direction of these intrusive areas is, as a whole, to the south-west, thus being approximately at right angles to the normal strike of the Silurian rocks of the district.

The immense forces connected with the intrusion of these rocks into the sediments may be inferred from the observation that in places these latter have been deflected from their normal strike, and lie alongside the intrusive rocks in a more or less east and west direction. This linear extension of areas of intrusive rocks across the direction of the prevalent strike I have also observed in places in the Omeo district, as, for instance, at Swift's Creek.

The prevalent strike of the Silurian strata in direction west of north indicates a direction of compression acting at right angles to it, and, I think, probably from the east. The east and west diversion of the strata in the neighbourhood of the intrusive area of Dargo is local, and may be due to pressure exerted by the molten magma when being thrust into the opening sediments. There was, I think, an elevation of the crust, accompanied by an upward movement of great force by the plutonic magma, which filled in and probably thrust back the opening strata. The best explanation of the phenomena which have imprinted themselves upon the rocks is one in this case which points to subsidence in an adjoining area to the eastward, probably beyond the present bounds of the continent, acting against a rigid part of the crust of the earth. By this the strata were forced to give way, and their movement was assisted by the upward thrust of the imprisoned magmas, acting under the weight of the subsiding area, as fluids under hydrostatic pressure. The weakest portion of the crust gave way, and elevation was the result. The accumulation of the immense thicknesses of the Silurian formations, estimated by Dr. Selwyn as being at least 35,000 feet,* implies a long-continued period of depression.

My own observations in Gippsland have shown me reason to believe that the south-eastern part of Australia, as evidenced in the Australian Alps, was subject to extensive elevation at the close of the Silurian age, which culminated in a volcanic period, evidenced by the Snowy River porphyries, which are stratigraphically between the Upper Silurian strata and the Middle Devonian beds of Buchan.

The compression of the Silurian formations into acute folds, together with elevation of the crust, would tend to give room to the imprisoned plutonic magmas when forced into the rising crust of the earth. Such movements as these must have been necessary to produce the results which denudation has laid bare at Dargo and the adjoining areas.

The contact rocks produced by the action of the plutonic masses upon the adjacent sediments are mainly varieties of schistose and crystalline hornfels, normal in their character, and not differing materially from similar rocks which have been observed and described in other parts of the world.

One of the most interesting features in connection with the Dargo and neighbouring areas are the auriferous quartz lodes at the contacts. Their interest and importance do not arise out of their economic value, which is small, but from the light which their study is calculated to throw in the future, not only upon their own origin and formation, but also on that of auriferous quartz reefs generally.

In these notes I have described the relations of the contact quartz lodes and veins to the adjoining formations, and I shall now speak of the quartz reefs in the Silurian tracts at a distance from the intrusive areas.

The quartz reefs and smaller veins in the Silurian formations of North Gippsland were formed after the sediments were invaded by the plutonic rocks, and before there had been complete subsequent cooling and consolidation. The limits of this space of time are fixed by the folding together of the Silurian strata† and the complete stratigraphical

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* Intercolonial Exhibition Essays, 1886. Notes on the Physical Geography and Geology of Victoria, p. 11.

† In parts of North Gippsland the Upper Silurian beds have been folded in this manner, as well as the Lower Silurian.

break below the Upper Devonian formations. The quartz veins cross, or are contained in the former, but do not, wherever the contact of the two formations can be observed, pass up into the latter; indeed, the lowest beds of the Upper Devonian series are made up largely in places of quartz pebbles derived from the denuded Silurian rocks.*

As an illustration of the Silurian tracts in which auriferous quartz reefs are found, I take the district north of Dargo for brief reference. A mental picture of it will be of a great tract of highly-inclined, alternating quartzose and argillaceous beds, rising to over three thousand feet above its lowest valleys.

The total thickness of these Silurian rocks is much greater than the depth from the highest mountain summit to the deepest valley, for within them there are no traces of the nearness underfoot of the plutonic rocks.

This great mass of sediments, which covers more than two hundred square miles between the Dargo and Wonnangatta rivers is traversed, as may be seen in the workings of mines, as well as in natural and artificial rock sections, by joints and fissures, the results of innumerable compressions, dislocations, elevations, and depressions by which the strata have been affected. Very many of these lie in the direction of the strike, but others cross it, as well as the dip or the cleavage, at various angles. They all form, when taken in the aggregate, as compared with the great mass of mountains, a more or less connected network of separations in the rocks. Many of them are only planes of discontinuity, but others have been filled by vein quartz from several feet in thickness down to the width of scarce more than a sheet of paper. The fissures thus filled by "reefs" of quartz have in their turn been faulted, so that in many places the following of them in mining is a matter of great difficulty.

In certain localities the quartz is more mineralised than in others, and here it is more usual to find the reefs payably auriferous. It may prove that in the area referred to, as in others, where it has been shown to be the case by the valuable researches of Mr. R. A. F. Murray, the auriferous quartz reefs lie within a certain band, according with the strike of the sedimentary rocks. In the district of which I am now speaking, and of which Grant may be taken as the centre,

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* The occurrence of such conglomerates suggests that the lowest beds of the Upper Devonian series may in places be auriferous.

veins of quartz occur throughout the mass of the Silurian formations from the summits of the mountains down to the bottoms of the deepest valleys. The great thickness of these rocks, which has been denuded during the long continuance of terrestrial conditions in the Australian Alps, was also similarly traversed by quartz veins, as is proved by the quartz gravels of the old rivers of Middle Miocene age which are now situated almost on the summits of the mountains, more or less covered up by flows of basaltic lava.*

To complete the mental picture, one must also conceive the Silurian strata with their quartz veins, extending downwards to the plutonic rock masses—at whatever depth below the present surface these may be situated. This inference is fully justified by that which one can observe at places where, as at Dargo, denudation has laid bare the contact of the two formations.

In endeavouring to explain the formation of the quartz reefs in this vast mass of Silurian sediments, which is only the remains of a once much larger mass, it seems to me that one is forced to assign as a cause the action of solutions which have derived their silica and their gold also from the strata through which they have percolated. Herein they are distinguished from these quartz veins to which I have before referred, which are found in the plutonic rocks, or in the schists immediately adjoining them.

If I am correct in saying that they were formed during the interval of time from the close of the Upper Silurian period to the close of the Middle Devonian period, then it is probable that their formation was due to causes which lay between two extremes. That is to say, to solutions intermediate in character between those which existed at the time of the invasion of the sediments by the plutonic rocks, or to those which existed at the time when the plutonic action had abated or had almost died out. The former would be mineralised solutions acting under a high temperature and great pressure; the latter would be solutions remaining after a long course of mineral regeneration, and under conditions of much lowered temperature and pressure. The action of solutions of the former kind seems to have been towards the regeneration of the sediments as metamorphic schists. As to the latter, we may suspect that they were most likely

* The plant beds contain, among others, Cinnamomum polymorphoides (M'Coy).

to deposit those combinations which had remained in solution the longest, or which had been taken up from the rock masses through which they circulated. I think reasons can be shown for believing that silica would be amongst those substances, and also gold.

If the quartz reefs were formed, as I believe, towards the close of the period of plutonic and volcanic activity, it may not be necessary to assume any great elevation of temperature or of pressure to account for their formation. Indeed, as I have before said, the deposition of the quartz from solutions, and the production of the ores found in the contact lodes, would be most likely to take place at a falling temperature, when the solutions were no longer so well able to carry their mineral burdens.

But there is another view which must be considered when looking round for the probable source of the silica which we now see as the quartz of the reefs.

We learn from the investigations of Mr. J. Cosmo Newbery, C.M.G., that the waters percolating from the surface downwards are charged with ammoniacal compounds of which the acid carbonate is the most energetic in its action on the silicate rocks. He has shown that ammonia can be obtained from almost any, if not all, of our springs and subterranean waters, and that "such ammoniacal solutions, especially that of the acid carbonate, can carry away silica in solution, and penetrating to great depths become no doubt one of the active agents in metamorphism." *

It is probable that such agencies which are now active may have been just as powerful in the time when these quartz reefs in question were formed. That time was one of volcanic activity, and probably of a land surface, and if such were the case the waters percolating down into the earth would be ammoniacal, and at times strongly so.

It is, however, not probable that one set of reactions only was concerned in the formation of the quartz reefs. The silica may have been present, not only in solutions in the manner suggested by Mr. Newbery's experiments and researches, but also as a residuum in much older solutions which had taken part in metamorphic processes.

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* Reports of Progress Geological Survey of Victoria, Part IV. and Part V. Laboratory Report, page 166, *et infra*. "Formation of Hyalite by the Action of Ammonia"—Transactions of the Royal Society of Victoria, Vol. XV., page 49.

It remains now for me to point out a possible source of the gold contained in the reefs. It might be considered that the gold and silver found in the contact reefs had an origin connected with the plutonic masses, but this explanation would not apply to those reefs and veins which are to be found in the Silurian rocks spoken of by me previously.

Sonstadt* has proved the existence of gold in sea water, and, according to Wurtz,† it is therein at the rate of one dollar in value to every twenty-five tons of water. Such being the case, it seems probable that the waters of the Paleozoic oceans did not contain less gold in solution than those of the present time. The deposition of the enormous thickness of Silurian sediments,‡ much of which consisted of fine silt and mud containing organic substances, must have necessarily included a certain amount of sea water. This, although as to some of the elements and combinations —as, for instance, gold—a solution of extreme dilution, yet would, in the aggregate, contain an enormous amount even of the rarer elements. Hence these sediments must, on this view, have included a large amount of gold diffused through them in solution, possibly, as at the present time, in combination with iodine.

The observations and experiments of Daintree, as confirmed by Wilkinson,§ show that the solution of gold chloride is precipitated in the presence of organic substances. The occurrence of auriferous pyrites deposited upon a piece of wood taken from the drift immediately below the basalt at Ballarat‖ and of gold deposited upon coal at Vöröspatak¶ still further illustrates this reaction, and, as relates to the former instance, it shows that even in recent times subterranean waters conveyed gold in solution. That they

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* Roth—*Chemische Geologie*, Vol. I., p. 492.

† Hunt—*Chemical and Geological Essays*, p. 237.

‡ "Making due allowance for this repetition of the same beds at the surface, the total vertical thickness of the series can scarcely be estimated at less than 35,000 feet." Intercolonial Exhibition Essays, 1866. "Notes on the Physical Geography, Geology, and Mineralogy of Victoria," by Alfred R. C. Selwyn and George H. F. Ulrich, p. 11.

§ Mr. Daintree's discovery consisted in the fact that a speck of gold lying in a solution of chloride of gold increased to several times its original size after a small piece of cork had, by accident, fallen into the solution. This was confirmed by further experiment by Mr. Chas. Wilkinson. Ibid, p. 24.

‖ Ibid, p. 56. The pyrites gave a yield, on assay, at the rate of 40 ozs. of gold per ton.

¶ Recorded by K. V. Fritch. Roth—Chemische Geologic, Vol. I., p. 602.

do so now is shown by the observation made by Mr. H. Y. L. Brown in the Alison mine at Costerfield, where a mammillary, or stalactitical crust, had been deposited on the roof of one of the drives, which contained gold, together with ores of iron and antimony.*

Such sediments as those of Silurian times could not lose their saline waters until they became elevated above the sea level as dry land, and this seems only to have been the case with them during the earlier part of the Devonian age, as a consequence of the great terrestrial movements to which I have before referred. So long as the saline waters remained within the sediments they would afford materials for mineral regeneration. The gold in solution, or possibly also diffused in a metallic, finely-divided state within certain beds, if precipitated by organic substances, would be a source of supply under a series of reactions which are conceivable, as also the final deposition of the gold, together with silica, in the fissures which gave passage to the solutions.

It would be idle to attempt to sketch out the course of such reactions in the absence of knowledge as to the effect of the very different conditions of temperature and pressure at great depths within the earth. It suffices for my purpose if I have been able to indicate the possible source of the gold and the mode of its final resting-place in the quartz reefs. The experiments of Daintree and Wilkinson suggest the precipitation of the gold in solution by organic materials in the sediments; and as to the formation of the quartz reefs, together with the gold, the experiments made by Bischoff† show that the mutual reaction of solutions of gold chloride and alkaline silicates may have played a part.

The following are the conclusions to which I have arrived on the foregoing subjects:—

(1.) The Silurian sediments included a certain amount of the waters of the seas in which they were laid down, and thus contained some of the materials for their mineral regeneration and the formation of metalliferous lodes.

(2.) The folding, compression, metamorphism, and invasion by plutonic rocks of these sediments occurred at the close of the Silurian age, followed by—

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* J. Cosmo Newbery, B.Sc., Laboratory (page 175)—Reports of Progress, Part IV., Geological Survey of Victoria.

† *Lehrbuch der Chemischen und Physicalischen Geologie* (Part III., page 843).

(3.) The elevation of the crust of the earth to a land surface during the early part of the Devonian age, and the manifestation of plutonic action in volcanoes (Snowy River district).

(4.) The cessation of the plutonic and volcanic action and the subsidence of the land in the Middle Devonian period.

(5.) The intrusion of the quartz diorites of Dargo was probably during the latter part of the time mentioned in (2).

(6.) The formation of the auriferous contact and other quartz reefs of the district referred to in these notes was probably in some part of the time mentioned in (3), if not in the earlier part of (4).

These, then, are the general conclusions which I have reached as to the origin and formation of the auriferous reefs of North Gippsland, whether at the contacts or in the Silurian formations. The tentative hypothesis which I have briefly sketched pretends to no more than an attempt to throw some light into the dark places of a most difficult subject. Whether I have in any measure approached a solution of the question I must leave to competent authorities to decide, merely adding that, from my point of view, the hypothesis seems to harmonise with observed facts, and not to run counter to the requirements of geological chemistry.

My views, if resting on a foundation of truth, would have an important bearing upon the question of the future continuance of our quartz reefs in depth. It would follow as a corollary to them that the quartz reefs in any part of Victoria might be expected to descend in a more or less connected manner through the whole thickness of the Silurian formations, and to end only as contact lodes at the subterranean plutonic rocks.

EXPLANATION OF THE PLATES.

PLATE I.

Horizontal plan of middle adit at the Exhibition mine, Orr's Creek, Dargo, looking west. The numbers 1, 2, 3, 4, refer to the sections given in the plate across the adit.

Fig. 1. (*a*) Quartz vein six to nine inches wide, with gold, accompanied by galena and ordinary iron pyrites. (*b* and *b'*) Narrow quartz veins carrying gold, very finely divided, and being in places merely thin partings. (*c*) Hornfels rock.

Fig. 2. (*a*) Dyke of much decomposed igneous rock. (*b* and *b'*) Quartz veins with gold, arsenical and iron pyrites. (*c*) Hornfels.

Fig. 3. (*a*) Quartz vein, with gold and pyrites. (*b*) A narrow clay seam. (*c*) Hornfels. The portion of country included between *a* and *b* is much mineralised.

Fig. 4. (*a*) Quartz vein, with gold and iron pyrites. (*b*) Decomposed dyke of quartz porphyr. (*c*) Hornfels.

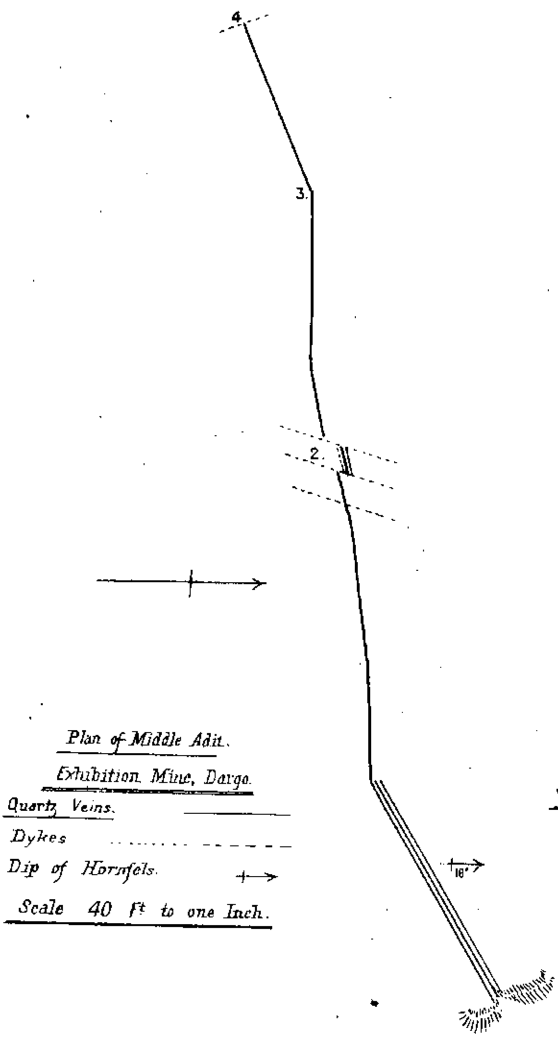
Plate II.

Fig. 1. Section of reef at the Eureka mine, Tucker Creek. (*a*) Quartz-mica diorite. (*b*) Quartz vein about 18 inches in width, with pyrites and a little gold. (*c*) Porphyrite dyke. Dip to the east.

Fig. 2. Section of lode at Budgee Budgee mine, Granite Creek. (*a*) Quartz-mica diorite. (*b*) Mineralised band of diorite, carrying copper pyrites. (*c*) Clay seam. (*d*) Quartz vein, with gold and pyrites. (*e*) Quartz-mica diorite. The lode dips north.

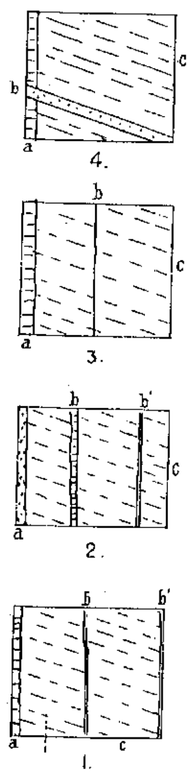
Fig. 3. Ground plan of the reef in the Exhibition mine, showing the manner in which "splices" take place between the main vein and smaller veins of quartz from the northern side. (*a, a', a''*) Quartz veins, with gold, galena, and iron pyrites. (*b*) Hornfels. (*c c'*) Walls of the lode country.

Fig. 4. Section of the strata at Stringer's Creek. (*a* and *c*) Fine-grained sandstone. (*b, d* and *f*) Fine-grained slaty rock. (*e*) Sandstone, coarser grained than *a* and *b* and having much argillaceous material, together with grains of quartz. In this rock are numerous narrow veins of crystallised quartz (*g*) which do not pass into the beds on either side. In places these veins can be seen to have been filled by quartz crystallisations, commencing at each side and meeting in the middle. Under the microscope a thin slice of this bed shows that a considerable silicification has taken place throughout the rock, and that the filling of the transverse veins has in all probability been connected therewith, leaving the slaty beds adjoining but little affected. The slaty cleavage, which has affected the beds *b*, *d*, *f*, has not acted upon *e*.



Plan of Middle Adit.

Exhibition Mine, Dargo.



Sections across Adit, Exhibition Mine, Dargo.

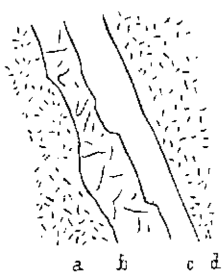


Fig: 1.

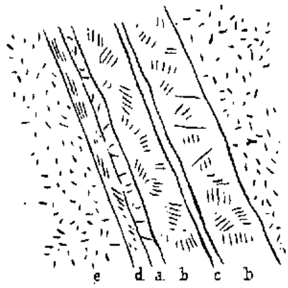


Fig: 2.

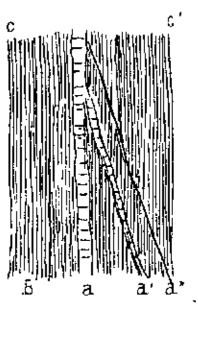


Fig: 3.

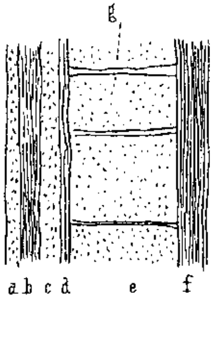
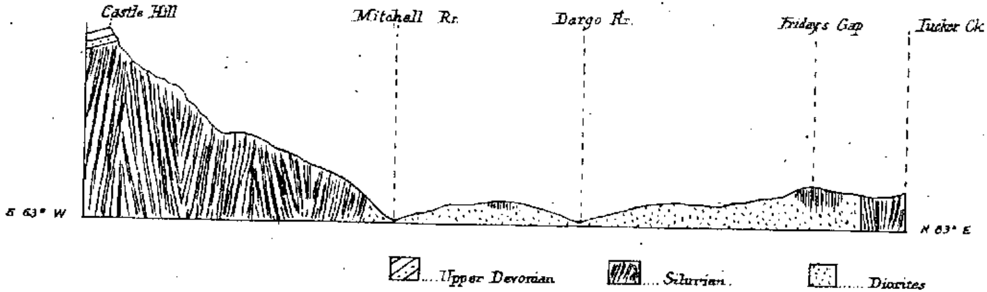
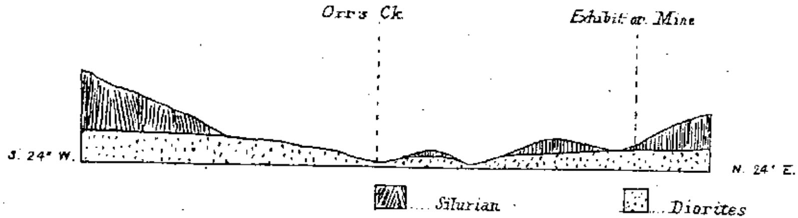


Fig: 4.



Sketch Section across the Dargo Area.

Scale. { Horizontal 8 miles / Vertical 4000 ft } One Inch.



Sketch Section across Orr's Ck. Dargo.

Scale. { Horizontal 40 Chains. / Vertical 2500 ft. } One Inch

Plate III.

ART. XIII.—*On the Sections of the Delta of the Yarra, displayed in the Fisherman's Bend Cutting.*

BY A. H. S. LUCAS, M.A., B.SC., F.G.S.

[Read 14th October, 1886.]

THE raised beaches around the shores of Port Phillip—at Portarlington, Frankston, Cheltenham, Brighton, &c., everywhere marked where the cliffs are high enough to prevent any confusion of the old with the present shores—have a great interest in their bearing on the question of the changes in physical features which have taken place in the Port Phillip district in post-tertiary times. The task of collecting evidence of any value is, however, tedious, and as the shells of these deposits are in the eyes of zoologists not quite recent, and in those of geologists scarcely fossil, they have not attracted the serious attention of working naturalists. Usually met with in natural cliff-sections, or laid bare on the present shores, all more or less weathered, fractured, and fragile, these shells and their record have not yet been diligently read. Yet a careful study will repay those who would accurately determine the changes which have taken place about our coasts during the recent period.

A special opportunity has occurred of examining these post-tertiary deposits at a distance from the sea, and in extended and freshly-exposed vertical sections, in the ship canal, or straight cut, recently completed to enable the shipping to avoid the dangers and delays of the Fisherman's Bend. My attention was directed to the matter by Mr. D. Davies, of the Melbourne Harbour Trust; and after paying a visit to the canal I fully agreed with him as to the importance of preserving a record of the sections, certainly the most extensive hitherto obtained, or likely to be obtained in the future, of the beds which form the delta of the Yarra. Accordingly I have paid several visits to the ground, noted the stratigraphy carefully, and collected as many relics of life and traces of mineralisation as possible in the somewhat limited time that has intervened between my first visit and the admission of the water. I have to tender my thanks to the Commissioners and the chief engineer of the Melbourne Harbour Trust for permission to make use of the data of precision, the plans and borings, prepared for the construction of the canal; and I must also make my acknowledgments to Mr. Davies and Mr. Meldrum, of the Trust, who have given me very ready and intelligent assistance in the inquiry on the spot.

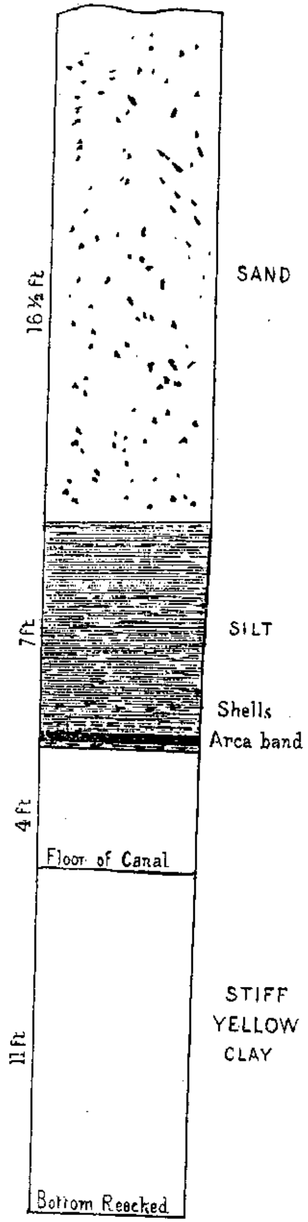
The canal is 6000 feet in length. It forms a curve, with 6000 feet as its shortest radius, trending nearly east and west, and roughly conformable to the north shore of Hobson's Bay. The average distance from the Bay is 7200 feet across the Sandridge flats; the west end of the canal is 4600 feet below the confluence of the Saltwater and Yarra, and 12,600 feet from the sea extremity of the stone walls, both measurements being taken along the present watercourses. The width of the canal at low-water is 260 feet, and the depth of the exposed excavation prior to the dredgings 20 feet below low-water mark. I may say that there is no appreciable difference between the level of low-water in the Bay and at Falls Bridge. The surface of the ground being about 7½ feet above low-water, the total vertical depth of the sections exposed was 27 feet; at one point the depth reached 31 feet.

Throughout the canal the appearance and sequence of the beds excavated are as follows:—The floor and the lowest part of the walls to a height of 4 feet on the average consist of a stiff yellowish clay, in which no traces of life have been detected. The greater part of the side walls is formed of a compacted, fine-grained black silt, having an average thickness of 7 feet. Above the silt is a capping of sand, with an average thickness of 16½ feet, and reaching to the surface. Both silt and sand contain marine shells. The sections are fairly uniform from end to end of the canal, though the silt drops from 8 feet to 5 feet from W. to E. Only in one notable depression, to be dwelt on at a later stage, does the silt dip below the floor of the cutting, and in no case does it come within 13 feet of the surface of the ground.

The upper surface of the very stiff yellowish clay, as shown in the face of the sides, is roughly horizontal with irregular undulations, whose amplitude never exceeds 3 feet. There is but one marked inequality in the general level, the exceptional depression referred to. The hollow is filled with silt, continuous in bedding with the main mass. The

COODE CANAL

Vertical Section



average depth below low-water mark of this upper limit of the clay is 16 feet. The bed of the canal is 4 feet lower, and the clay was still found to be present in a channel cut 11 feet deep in the floor for the passage beneath the canal of the Yan Yean main water-pipe. How much deeper the clay extends is not known, but it has thus been traced for 15 feet. No animal or vegetable remains have been found in this clay, but Mr. Davies informs me that he has obtained nodular concretions at one point.

There is, as we have said, one remarkable exception to the general uniformity of level in the surface of this unfossiliferous clay. This occurs in the form of a linear depression stretching across the canal near the east end. As seen in the floor of the canal, the sharply-defined borders are two parallel lines running across the floor, with a trend N. 30 degs. W., S. 30 degs. E., and making an angle of 45 degs. with the banks of the cutting. The perpendicular distance between the borders is 200 feet, and the distance of the centre of the parallel band from the east extremity of the canal 550 feet. As seen in the sides the sections of the depression are gently sloping curves of slight concavity. This hollow is filled with the black silt, and the shell-layers dip into it with a corresponding curvature. It is evidently, I think, an old channel of the Yarra, or of one of its estuarine branches.

Above the clay lies a thickness of about 7 feet on the average, increasing to 10 or 12 feet towards the east end, of blue-black silt, of estuarine origin. The lowest stratum of this silt, resting on the clay conformably to the curvature of its very moderately undulating surface, is a remarkable layer of about 15 inches average depth, crowded with marine shells, all of species still to be found in the Bay. Near the surface of junction a thin layer forms a conspicuous white band, which, as one stood on the summit of one bank of the canal, could be traced readily by the eye, extending throughout the visible portion of the opposite slope. The usual thickness of this band was 3 inches, but in some places it divided into two, or even three, branches; but these were exceptional, and never occupied a greater thickness than a few inches. It was composed of thousands of specimens of *Arca trapezium* (Desh), with a large number of oysters, *O. edulis*. Both species assuredly lived on the spot, as evidenced by the greater number occurring with the two valves united, and by the presence of multitudes of individuals of all ages and sizes. The enormous number of shells crowded into this layer, and the vast areal space occupied by it, will be realised by anyone who sees large portions of the new-made ground on the Port Melbourne side of the river covered with the valves of the arcas and oysters. The bed had been previously reached in the river dredgings, but its exact position and dimensions had not been determined.

It was suggested to me that the arcas and oysters were all killed by an incursion of fresh water, as the upper limit of the arca bed is apparently definite, and the dense deposit of silt commences above. But as the casts of the shells are of the same silt as occurs in mass above—as marine shells occur, more or less, throughout the silt, while scattered arcas are to be found, though rarely, amongst the shells of the lower layer of the silt—it is clear that there is no evidence of fresh-water influx. The deposit of shells ceased, probably because the depth of salt-water became no longer sufficient, and the arcas and oysters migrated outwards to deeper waters. The bivalve shells, too, all contain a core of silt, which has contracted on drying, so that the silt cast is smaller than the cavity of the shell. This would not have been the case had the shells been filled with mud from above. The oysters are fine specimens of the mud-oyster, often 6 inches across.

In addition to these, the two most prevalent forms, I also obtained the following from the lowest 18 inches of the silt:—*Cardium tenuicostatum,* Lam.; *Mytilus latus,* Lam.; *Natica conica,* Lam.; *Cominella alveolata,* Kilner; *Ampullarina fragilis,* Quoy.; *Cylichna arachnoides,* Quoy.; *Philine Angasi,* Sow.; *Venus lævigata,* Lam.; *Tellina deltoidalis,* Lam.; *Nassa fasciata,* Lam.; *N. pauperata,* Lam.; Balani, Polyzoa, Driftwood.

Several fragments of driftwood were found on the arca horizon. One piece was covered with balani. I am indebted to Mr. Meldrum for pointing out to me one fine trunk, ten inches in diameter, in the part exposed, lying just on the top of the yellow clay. The quantity of wood no doubt indicates the estuarine origin of the silt, and the comparative freshness and excellent state of preservation of the driftwood bears witness to the imperviousness to water of the protecting silt.

The arca band extends continuously throughout the cutting at about the same horizon. Mr. Davies also noted it at the same level in a slip cut 500 feet north of the canal.

I have already said that the bed has been met with in the river dredgings, but I have no record of the reaches of the river in which the shells were found. Captain Synnot informs me that when digging out his dock near what is now Langland's Foundry (close to Wright and Orr's present dock, and a mile and a half from the nearer entrance to the canal), he came upon shells, and Mr. John Macaulay, who acted as foreman during the construction of the dock, assures Mr. Davies that the shells were those of the "Blood Cockle," which is the old colonists' name for the arca. I can obtain no evidence of shells having been found in Wright and Orr's new dock. In the river bed the silt ceases, as we go up stream, at about the crossing of the Steam Ferry, at Spencer-street; at and above this was a patch of rock which has been removed by the Trust. The rock crops to the surface again at the Falls Bridge, and occurs as more or less of an obstruction to a point about 300 yards above Prince's Bridge. Where the rock is covered above the ferry the covering consists, as far as I can learn or judge, of the yellow clay; but silt may exist as flood deposit, not, I expect, as a strictly estuarine deposit, in the South Melbourne swamps. I had purposed paying a visit of inspection to the cutting for the Yarra embankment, above Falls Fridge, but the water got in, I believe prematurely, and I was prevented from carrying out my intention. I have not, therefore, been able to ascertain whether the arcas occurred here or not. I think not, but, from actual observation, the arca bed has been found stretching to a distance of three, and perhaps five, miles inland from the present shore.

I have made inquiries into the present habitats and distribution of the two molluscs characteristic of this bed. Though I have taken considerable pains during my four years' residence in Melbourne to acquaint myself with the locale and habits of the mollusca of the bay, I have never seen living *animals* of *Arca trapezium*. I have found live shells thrown on the shore between Brighton and Cheltenham, and dead shells are frequent on the sands between St. Kilda and Sandridge. I have dredged in Laverton Bay and at Sandridge, but never obtained living specimens; still I believe the animals are living somewhere off Williamstown. Mr. Tope informed Mr. Davies that he had taken the animals alive many years ago near Williamstown; and Mr. W. Kershaw, of the National Museum, obtained them by wading near the mouth of the river on the Sandridge shore.

Rev. J. E. Tenison-Woods, in his "Census of Tasmanian Shells," quotes *A. trapezium* as "frequent at Tamar Heads at low water." But on communicating with my friend, Lieut. Beddome, of Hobart, a high authority on Tasmanian shells, he forwards to me specimens of *A. fasciata* as being the species abundant among the rocks at Tamar Heads. I have often found *A. fasciata* in holes in the rocks just below low water at Williamstown, Cheltenham, &c. I think that *A. trapezium* occupies muddy bottoms, in comparatively deep water.

With regard to the present habitat of the mud oyster, Mr. Bracebridge Wilson writes me that he has dredged them alive in Corio Bay. I have it also from Ernest Myers, a Sandridge fisherman, that they are occasionally to be found in Port Phillip. Mr. Wilson says that the dead shells are abundant in the South Channel, and adds that a fisherman, named Mentiplay, used to dredge live oysters for sale from that locality.

The silt is very fine, and is from pressure compact and impervious to water. That this property has been of service in the preservation of the shells is seen from the effect produced upon them when exposed to the action of the river water. I have never found any concretions in the shell-layer in the canal itself. They are frequently brought up in dredging from the river. Mr. Davies obtained them *in situ* from the shell bed in the slip mentioned as cut some 500 feet from the east end of the cutting. No water came out of the silt until the shell band was reached; then water oozed out in quantity. I have no doubt that this was derived horizontally from the river, and that the access in this way of river water has produced these calcareous concretions. The smaller shells, where acted upon by water, have yielded up to it their lime, and this, carried in solution, has penetrated between the grains of silt, uniting them into an excellent "cement." The heart of the concretions is still dark silt. All stages of the process are visible from the unaltered shells, still distinct in outline, though united into a cluster by a hard cement, until we reach the nodular concretion of indefinite shape. In the case of the thinner shells only has the process been completed. The thick dense shells of the arcas have in very few cases yet succumbed, but they manifest signs of the initial stages.

The silt continues above the shelly stratum for 6—12 feet. It consists, no doubt, of the fine mud brought down by the old Yarra, and is almost as fresh, though more consolidated, than that now to be dredged off Williamstown. On burning a small fragment by way of experiment, I found that it formed a red and, I should judge, not very bad brick. No bones of mammals have been detected. I looked very closely for any fresh-water signs, but no Unio or Corbicula rewarded my search. The whole was almost certainly estuarine in formation, though the upper part of the silt was generally devoid of animal remains of any kind.

The junction plane of silt and sand is distinct. There is no break in the conformity. The lower layers of the sand contain next to no shells. At the east end of the excavation the vertical section of the sand exhibits much cross-bedding, due to play of currents, but I could see no trace of shells. The sands here were bound together in places by a ferruginous cement, and preserved a vertical face. At the west end, on the contrary, the sands were very loose, and at about the level of present low-water mark (or a foot below) a very good example of an old beach is preserved in the form of a narrow 4—6 in. band, crammed with remains of shells such as one finds nowadays piled on the shore near low-water mark at Sandridge. Dead shells most of them, some bored by Naticas, while some few sand burrowers, as *Solen*, *Pholas*, and *Mesodesma*, clearly lived on the spot. How far this layer of shells extended along the canal I am unable to say, as the sands of the side-slopes towards the west had, from their incoherence, to be protected and covered by sheet-piling and pitching, even on my first visit to the ground. The west end of the canal is over 2 miles from the present shore of Hobson's Bay along the river.

Up to this shell-band, then, the sands are of marine origin, brought up by currents probably from the cliffs of Brighton, Cheltenham, &c. At Cheltenham the bed of shells occurs at a height of nearly 60 feet, and, as the cliffs were rising to this elevation, the wear and tear must have been very great. As the sand spread over the silt, a corresponding immigration of Solens and other sand-inhabiting forms took place. But the uppermost layers of sand have, I believe, not been laid down by water, but been blown in from the shores of Hobson's Bay. The process is, in fact, still going on where unchecked by vegetation, and where the Sandridge people have stripped the surface of fern it goes on with unpleasant rapidity. The actual surface consists of a series of long rolls, whose axes run approximately parallel to the present shore line. In some cases a single roll can be traced continuously for two or three miles. The axes are also at right angles to the prevailing winds, running E. and W. In the established land the ridges are sandy, and grow bracken only, while the hollows in which water has been able to lie yield a good soil, often even a solid turf.

The silt holds water. In consequence a difficulty was encountered in making the canal, for the surface-waters, accumulating on the top of the silt, emerged as springs or oozed from the sides of the cutting. The vegetation, chiefly bracken, of the surface has formed a certain amount of humus. The atmospheric waters passing through have become sufficiently impregnated with acids to dissolve the iron of the (probably basaltic) sands, and appeared as reddish-brown streamlets, disfiguring and injuring the slopes of the work. Wherever the course of such a runnel is arrested—as where it flows over a tiny fall into a miniature pool—a foam is thrown up, which, from its soapy touch and ochreous colour, reminds one of meerschaum. I made, with the aid of my pupils, a rough analysis of the solid constituent of the foam vesicles, and found that it was a compound silicate of aluminium, with a good proportion of ferrous oxide and traces of ferric oxide, but with no magnesia. The water percolating through the sand takes up other matters in solution, and, upon evaporation at the free surface exposed to the atmosphere, leaves the solids as incrustations. Such white and yellow patches were here and there conspicuous, both on sand and silt below. The white incrustations consisted of sodium and magnesium chlorides, and the yellow of ferric chloride.

The silt forms the greater part of the West Melbourne Swamp, and betrays there also its estuarial origin. Mr. Davies has shown me the skull of a dolphin found 10 feet below the surface at one point, and others have been obtained. Mr. Bale, F.R.M.S., has furnished me with a list of diatoms found in the deposits of the West Melbourne Swamp, which are notable for their richness in those organisms. The list is not exhaustive, but includes all the commoner forms, and these, without exception, are proper to brackish or salt water. The species comprised *Campylodiscus Dœmelianus*, *C. echeneïs* (= *C. cribrosus*, *C. argus*), *C. clypeus*, *Synedra gracilis* (= *S. pulchella var.*), *Nitzschia tryblionella* (= *T.*

gracilis) var., N. circumsuta, Melosira Borreri, Hyalodiscus Californicus, Actinocyclus Barklyi, Navicula Yarrensis, N. Smithii, Surirella craticula (so called, = *Navicula sp.), Epithemia musculus.*

As this is a record of facts, while I have endeavoured to show their immediate bearing and connection, I have abstained from any wide speculation as to the past history of the Lower Yarra. I do not think that the depth of the silt is at all an accurate measure of the time that has elapsed since the arcas and oysters lived. Soundings made in Hobson's Bay by Mr. Moseley in 1867, 1869, 1871, and 1878, and by Captain Stanley in 1875, showed that over the western part of the Bay there had been in the eleven years a general deposit of 12 to 36 inches of silt. The area within a radius of a quarter of a mile from Williamstown Pier had, however, not shallowed at all in the period. With variations from an increase of *nil* to an increase of 36 inches in eleven years we have no grounds for a choice of rate of deposition, nor reason for striking the average. It is advisable, then, to postpone any extensive generalisations until other parts of the delta have yielded further evidence. It is to be hoped that opportunities will be seized as they occur of recording such evidence.

Art. XIV.—*On the Sound Organs of the Green Cicada.*

Cyclochila Australasiæ, Donovan sp.

By A. H. S. Lucas, M.A., B.Sc., F.G.S.

[Read 14th October, 1886.]

Of all insects the cicadas have perhaps for the longest period attracted the curious interest of men of all nations and on all the continents. It is then not a little singular that there should be any disagreement amongst zoologists as to the precise manner in which these assiduous musicians produce their music. For many years Réaumur's explanation of the process, published in 1740, in his *Mémoires**, was generally received; but in 1872 Landois published a monograph on "Die Ton-und Stimm-Apparate der Insekten" in the *Zeitschrift für Wissenschaftliche Zoologie*, in which he advanced a novel theory on the subject. I have not been able to obtain access to the original paper, but Huxley† quotes Landois as contending that "the posterior thoracic stigmata are the vocal organs. These open into chambers, in the walls of which tense membranes are so disposed as to intensify the sound by their resonance." In this view clearly, then, the sound is a true *voice*, produced as in man by a modification of the tubes of the breathing apparatus.

This is a taking theory. Nor is it so easy for European naturalists, save on their travels, to verify or discredit it for themselves. Thus there is but one tiny British species, and that now only rarely to be found in the New Forest. The European forms cannot compare in size with some of our own, and with many exotic species. The life of the adult insect is a short one, and exotic specimens could not be taken to England to repeat their performances before a scientific jury. From the habits of the larvæ, the rearing of cicadas would be attended with great difficulty. Réaumur himself writes‡:—

"Heureusement que ces parties, les plus singulierès de l'extérieur de ces mouches, peuvent être bien vûes sur celles qui sont mortes; et que pour les étudier et les disséquer à l'aise il faudroit faire périr les cigales qu'on auroit vivantes; car je me suis trouvé engagé à l'ècrire leur histoire sans en avoir jamais entendu chanter une, et sans en avoir jamais possédé une en vie."

Anatomy certainly gave Réaumur the clue to the correct theory, but we need also to bring the rival theories to crucial tests by experiment in order to definitively determine between them.

I was much exercised, as every new comer must be, on listening to this noisy Victorian species for the first time in 1883. By dissection and a few simple experiments I made out what I conceived to be the *modus operandi*, and all my observations agree with the older theory of Réaumur,

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* Tome 5.

† *Anatomy Invertebrated Animals*, page 438.

‡ *Mémoires*, tome 5, page 149.

and do not confirm the newer theory of Landois. I read a few notes on the subject before the Field Naturalists' Club of Victoria soon after. In later seasons I have repeated and extended the experiments. As attention has been called to the subject lately by Professor Lloyd Morgan *, who from examination of the corresponding species at the Cape of Good Hope has also come to distrust Landois' explanation of the process, I have thought it well to put on record an account of our green cicada, in which the organs are conspicuous, and which can be obtained with the utmost freedom at midsummer.

As will be seen from the specimens and dissections, the organs are situated in the first two segments of the abdomen in the males, occupying a space about one-third of the entire bulk of the animal. This fact alone shows the importance of the structure to the insect in the struggle for existence.

By a comparison with the unmodified segments of the female we find that the sound apparatus of the male has been developed by a specialisation of the terga of the first abdominal and the sterna of the last thoracic and first abdominal segments, accompanied by a remarkable development of the muscles of the trunk of the same two segments, and a suppression of the muscles of the succeeding abdominal segment.

In the anterior membranous slope of the dorsal surface of the first abdominal segment, facing the thorax, a pair of elliptical, sclerous membranes are differentiated, one on each side. These are set obliquely to the long axis of the body, are convex backwards and upwards, and are strengthened with chitinous ridges running from the anterior and inner to the posterior and outer angle. These are the rattle-membranes, by the internal friction of which, of the ridges on each other when in rapid vibration, the sound is originated. These rattle-membranes are protected by a corresponding pair of stout plates which project forwards over them, from what is in the female insect a mere transverse ridge of the abdominal tergum.

The ventral modifications are no less remarkable. The confronting surfaces of the metathorax and abdomen, in close apposition in the female, diverge widely in the male,

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* *Nature*, Vol. 33, Feb. 18, 1886, p. 369

the greater portion of each becoming transformed into a pair of tense, delicate, translucent membranes, which constitute the inferior boundaries of air-spaces. The tension-membranes of the metathorax are the smaller, and look downwards and backwards; those of the first abdominal segment, much larger, look downwards and forwards. A chitinous ridge and band separate the two pairs transversely. In the ventral middle line a short, stout ridge connects inferior medial projections, a blunt spur from the metathorax, and a semi-circular plate from the abdominal segment, and serves for the linear attachment of the great abdominal muscles. Both pairs of these delicate membranes are likewise protected by two large chitinous plates, which arise externally to the legs in the metathorax, and are enormously larger than corresponding folds in the female. These plates quite cover in the white membranes.

A pair of huge muscles take their origin close together below, along the visceral aspect of the median ridge referred to, and with great antero-posterior extension proceed upwards and outwards, diverging as they rise, to terminate about a quarter of an inch below the rattle-membranes in broad, plate-like, rigid terminals. From these tendinous slips pass to the rattle-membranes.

Capacious air-spaces, which act as resonators, are formed by absorption or suppression of peri-visceral and muscular elements in the regions affected. The general boundaries of the air-space are—in front the muscles and viscera of the mesothorax; below the two pairs of tension-membranes; behind the muscles and viscera of the hinder abdominal segments; and above the rattle-membranes. But this space is subdivided into successive resonators as follows:—(1) Antero-lateral recesses, bounded by the rattle-membranes above, the muscles and their terminal plates within, and the anterior tension-membranes below; (2) median recess between the diverging muscles; and (3) the vast drum-like cavities behind the muscles and above the great tension-membranes, excavated at the expense of the normal abdominal contents.

The *modus operandi* is apparently this. The muscles contract, and by their tendons set the rattle-membranes in a motion which is perfectly free. Vibratory motion would have been hindered or prevented altogether by a direct insertion of the massive muscles into the rattle-membrane. The vibrations of the membranes produced by the friction of the horny ridges is communicated to the air of the resonators, probably in succession to the subdivisions in the order indicated, and the shrill chirp thus so strangely intensified.*

The experiments which lead me to assign these respective functions to the different organs are as follows :—

(1.) The sound was produced without diminution of volume in the living insect:

(a) When the wings were removed.

(b) In the abdomen, when the cephalo-thorax was removed.

(c) When the hard protecting plates, both upper and lower, were removed.

(2.) The sound could be produced, though with somewhat less loudness, by irritating or by artificially working the great muscles while fresh in the separated abdomen.

(3.) The sound was almost entirely lost on slitting the rattle-membranes in the otherwise unmutilated animal. The insect worked there as before, but the charm was broken, and its voice was lost.

(4.) Vibrations of all the white tension-membranes took place *without the sound*, but these always vibrated when the sound was given forth, those of the thorax with greater amplitude. The sound was not affected by even a large rent in the great tension-membranes of the abdomen. Thus these membranes serve probably to give greater freedom of motion to a larger volume of air in the resonators.

(5.) The corresponding segments of the abdomen in male and female insects are easily recognisable. In both sexes there are five segments, each of which carries a pair of stigmata on the under surface about midway between the middle line and the margin on either side.

The stigmata of the mesothorax are most prominent; they are provided each with a cover, consisting of a pair of valves, which close and open at irregular intervals, apparently at the will of the animal, like eyelids.

The stigmata of the metathorax can be seen also without any difficulty in situation exactly corresponding to their position in the mesothorax. A bristle can be passed through a stigma into the air-tube without passing into any of the

* In a brief note "On the vocal organs of the Cicada," Proc. L.S.N.S.W., August, 1886, Mr. Haswell accepts Réaumur's theory. He gives no experiment, but adds the idea that the strips of which the great muscles are composed act independently or successively. The American authors, as Packard, are orthodox believers in the older view.

air-chambers of the sounding apparatus. I separated the abdomen, produced the skirr in it, and then passed a bristle through the metathoraic stigma for a distance of nearly half an inch along the tracheid.

(6.) There was no connection between the times of the rise and fall of the cover for the stigma of the mesothorax and the sounding of the rattle.

To work out the question fully we need, further—(1) to trace the development of the organs in the pupa, which is rather difficult to obtain; (2) to compare the adult organs of the Green Cicada with those of the other species of the family. I believe that a graduated series of forms might be obtained in which, as in the successive stages of growth of an individual, we might trace the gradual progression of these singular sound-organs, from simple beginnings to the highly elaborated apparatus of the *Cyclochila Australasiæ.*

EXPLANATION OF PLATE.

Fig. 1. *Cyclochila Australasiæ.* Male insect, natural size. (*a*) Stridulating organ of left side.

Fig. 2. Side view of same, enlarged. Both pairs of wings have been removed, and also the opercular or protecting plates. (*a*) Rattle-membrane or stridulating organ; (*b*) great tension membrane of abdominal segment; (*c*) tension membrane of metathorax.

Fig. 3. View of separated abdomen from before. (*a b*) As before; (*m*) great muscles; (*t*) tendinous slips of same; (*p*) opercular plates covering stridulating organs.

Fig. 4. View of great muscles from behind. (*b m*) As before.

Fig. 5. Internal view of abdomen divided in longitudinal median section, from the left. (*a b m*) As before; (*o*) plate-like terminal of right muscle.

I am indebted to my accomplished friend and colleague, Mr. Frank Goldstraw, for the drawings in this Plate.

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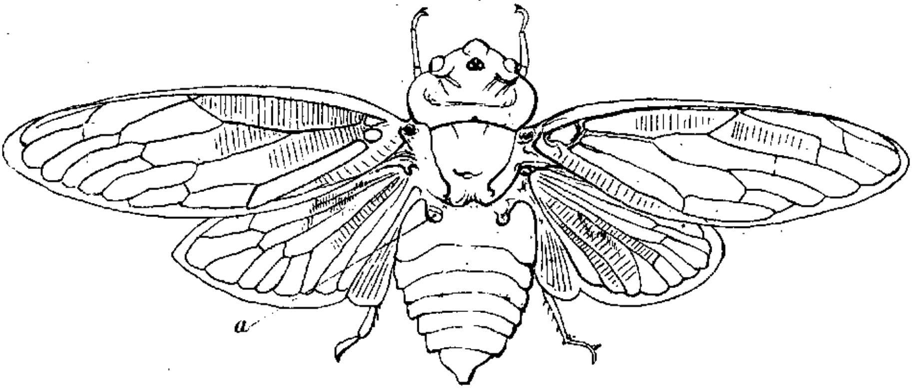

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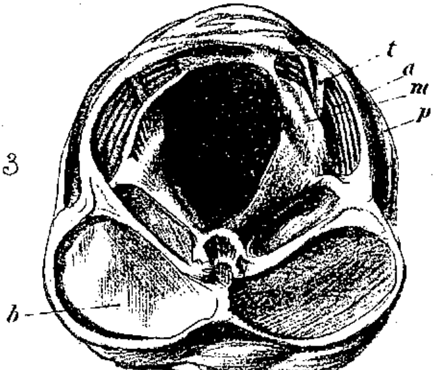

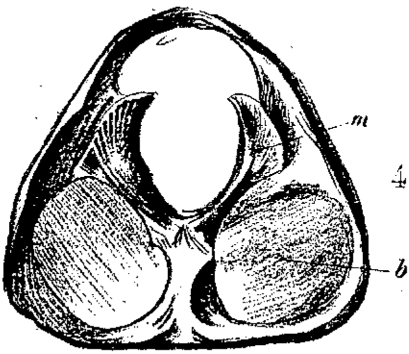

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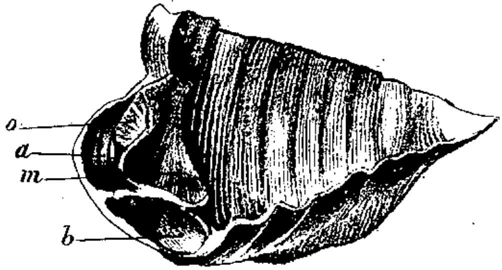

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Art. XV.—*Descriptions of New, or Little-Known, Polyzoa.*

Part XII.

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

[Read 11th November, 1886.]

Family Membraniporidæ.

Amphiblestrum argenteum, n. sp.

This species was described and figured in the Prodromus, of the Zoology of Victoria, Plate 37, as *Lepralia trifolium.* and subsequently referred to *Membranipora* in *Trans. Royal Society*, Victoria, 1881. It is not, however, the *Membranipora trifolium* of S. Woods, and, consequently, another name is required for it. The figures already given are quite correct, except that the oral flap in the membranous aperture is not shown. I give an amended description.

Zoarium encrusting. Zoœcia variously shaped, elongated, oval or rhomboidal, separated by narrow raised margins; lamina calcareous, finely granular, occupying about two-thirds of the area; aperture trifoliate, the lower margin straight or slightly convex, the entering angles rather sharp; two or three spines above, and frequently one close to each angle of the aperture. Oœcia of moderate size, globular, finely granular, sometimes with a narrow, smooth rim. Avicularia rare, between the zoœcia, with long, narrow mandibles.

Family Escharidæ.

Schizoporella rostrata, n. sp. Plate I., fig. 2.

Zoarium encrusting. Zoœcia rhomboidal, separated by narrow, sharply-raised margins, very slightly convex or nearly flat, silvery, with numerous faintly-bordered pores; mouth with a wide shallow sinus in the lower lip, and a minute denticle on each side internally; an elevated process immediately below the lower lip, on the inner aspect of which is an avicularium, with the triangular mandible pointed upwards. Oœcia large, globular; surface punctate or obscurely perforated.

Port Phillip Heads, Mr. J. B. Wilson.

Schizoporella pachnoides, n. sp. Plate I., fig. 3.

Zoarium encrusting. Zoœcia elongated, irregular in shape, separated by distinct grooves, with an elevated line at the bottom; surface minutely covered with small elevations, or, from the opening of these, white bordered pores; mouth lofty, horse-shoe shaped, with a wide, deep sinus in the lower lip; margin thickened, especially below; upper border becoming thickened and raised with age. An avicularium with the triangular mandible pointing straight or obliquely downwards, on a slight elevation below the mouth.

Port Phillip Heads.

Schizoporella dœdala, n. sp.

(= S. insignis, M'G.)

In the *Trans. Roy. Soc.*, Vict., 1882, I described a species as *S. insignis*, not being aware that the specific name had been a short time previously applied by Mr. Hincks to an African species. Mr. Hincks subsequently described the present species from Port Phillip Heads, referring it to Mr. Waters' fossil *S. conservata*, an indentification which is at least doubtful. As the specific name was previously used for another species, I propose naming the present *S. dœdala*, =*S. insignis*, M'G.=*S. conservata*, Hincks (not Waters).

Family CELLEPORIDÆ.

Lagenipora nitens, n. sp. Plate I., fig. 1.

Zoœcia oblique at the edges of the zoarium, erect towards the centre, smooth; primary mouth circular or sub-circular, with a small oval avicularium at one side; secondary mouth formed by a tubular peristome, separated by a narrow constricting collar; orifice with a spinous process on each side, between which is the original oral avicularium, carried upwards on a semi-spiral tube, widened above, and ending in a clavate projection. Vicarious avicularia broadly spatulate.

Port Phillip Heads, Mr. J. B. Wilson.

Of this interesting species I have only a very minute specimen on a piece of shell. It is related to Mr. Hincks's *Phylactella lucida*, afterwards referred by him to *Lagenipora*, and to his *L. spinosa.* The manner in which the small avicularium of the primary mouth is carried up on a semi-spiral tube with the growth of the peristome is very curious, and is precisely similar to what occurs in *Lekythopora hystrix.* On the specimen there is a single spatulate vicarious avicularium, similar also to those of *Lekythopora.* There are no oœcia on the specimen.

Family IDMONEIDÆ.

Idmonea atlantica, E. Forbes.

Two forms of this species occur, for specimens of both of which I am indebted to Mr. Wilson. Of one I have only seen a single specimen, three-quarters of an inch in height. The branches are dichotomous, and spread in nearly the same plane. The zoœcia are three to five in a row, the peristomes very long, the innermost the longest. The posterior surface is regularly longitudinally grooved in the growing ends of the branches, the ridges punctate; but in the older parts the ridges and intervening grooves are much obscured by a series of close concentric ridges, similar to those in *I. Milneana* and *interjuncta.* In the other form (var. *tenuis,* Busk) the branches are narrower, much more straggling, and the posterior surface has not the concentric ridges.

Hornera ramosa, n. sp. Plate I., fig. 4.

Zoarium branched, spreading; branches irregularly in the same plane. Branches rather narrow; anterior surface fibro-reticulate, the zoœcia opening in rhomboidal spaces. Zoœcia in three to five rows, orifices exserted, the central circular and entire, the lateral elliptical and pointed at one side. Posterior surface grooved, the ridges punctate and frequently separated by large punctations or vacuoles. Oœcia posterior, prominent, surface deeply areolated, frequently crossed by a narrow ridge starting from the aperture, which is nearly lunate and at one edge.

Port Phillip Heads and elsewhere.

I have some doubt whether this should not be considered a slender variety of *H. frondiculata,* which again ought possibly to be referred to *H. lichenoides.* It occurs in small tufts, occasionally attaining a diameter of an inch. The zoarium arises from a spreading, fibrillated, encrusting base, the resulting short stem immediately dividing into two or more. These again divide dichotomously, or give off smaller branches from the sides. The branches sometimes arise irregularly, and are slightly twisted on themselves, but they usually spread in a more or less flabelliform manner, frequently expanding laterally and occasionally having a penniform arrangement. The oœcia are very prominent and deeply areolated. They are occasionally crossed by a carina originating at the nearly lunate aperture; both ridge and opening are, however, frequently absent.

Family TUBULIPORIDÆ.

Liripora, n. genus.

Zoarium crustaceous, growing on a basal lamina. Zoœcia not projecting, arranged in single or multiple series, opening along the summits or towards the extremities of ridges which usually more or less radiate from a central point; the intervening grooves without cancelli and covered by a punctate, calcareous membrane.

The species which I have described as *Diastopora lineata* and *D. fasciculata* differ from the true *Diastoporæ* in having the zoœcia arranged in uni- or multiserial rows or ridges, and opening either along the summits of these ridges or towards their extremities. The intervening grooves or furrows have no cells or cancelli, but are covered by a more or less punctate, calcareous membrane. These differences necessitate the reference of the two species to a different generic group. I was at first inclined to place them under one of D'Orbigny's fossil genera, such as Actinopora, Discotubigera, Pavotubigera, or Semitubigera, the characters of which are generally essentially the same; but I think it more advisable to give a new name.

In *L. lineata* the ridges are frequently very much more elevated than in the specimen originally described and figured, and the zoarium, instead of being circular, is often elongated or irregular in shape. In all these forms the sloping margin of the zoarium, inside the edge of the thin lamina, is occupied by prismatic cells or cancelli, which open all round, and not only opposite the celliferous ridges. The orifices of the zoœcia are frequently closed by a punctate membrane. In some specimens of *D. fasciculata* the ridges and intervening furrows are much more distinct than in that figured.

Family DISCOPORELLIDÆ.

Lichenopora Wilsoni, n. sp. Plate I., fig. 5.

Zoarium discoid, cupped, the basal lamina free and upturned. Centre depressed, reticulated by narrow, rounded, smooth ridges or fibrillæ, with narrow, elongated interspaces, at the bottom of which is a punctate membrane; the elevated fibrillæ with numerous sharp, straight, or uncinate spines, projecting forwards. Zoœcia arranged in radiating lines of single series, erect, very lofty at the central starting point, and gradually diminishing in height to the circumference; mouth rounded, with usually a sharp spine on each side above. Intermediate cancelli numerous, large, irregular, with numerous minute internal spines.

Port Phillip Heads, Mr. J. B. Wilson.

The only specimen I have seen of this well-marked species forms a beautiful cupped disc one-third of an inch in diameter, the smooth edges of the basal lamina much turned upwards. The central depressed portion is occupied by a peculiar reticulation of smooth, round filbrillæ, from which numerous scattered, small, sharp spines project forwards. The zoœcia are also very characteristic. Those originating the series from the central reticulate space are very lofty; they rapidly but uniformly diminish in height. The peristome is produced on either side towards the upper part into a fine, sharp process. The cancelli between the zoœcial rows are irregular in shape, and lined with minute, sharp spines.

Family VESICULARIIDÆ.

Amathia inarmata, n. sp.

Zoarium much branched dichotomously; the branches articulated, thick; internodes short, each almost entirely occupied by a single biserial group of zoœcia, four to eight in each series, slightly diminishing in height towards the distal extremity. No filiform appendages.

This species differs from *A. lendigera* in the shortness of the internodes, which are each almost entirely occupied by a single group of zoœcia. The height of the zoœcia is also more nearly uniform.

A short time ago Mr. Cosmo Newbery placed at my disposal for examination some marine specimens collected in the Straits of Gaspar and Baly by Captain Worsley, of the telegraph ship "Sherard Osborne." They consisted chiefly of Crinoids, some magnificent specimens of Scalpellum villosum (Darwin), and a few Polyzoa. The last were all from the Straits of Gaspar, in lat. 3 degs. 19 mins. S., long. 107 degs. 17 mins. E., and were obtained from a depth of 17 fathoms. There are six species in all, of which three have been previously described. These are *Scrupocellaria cervicornis* (Busk) and *Nellia oculata* (Busk), both well-known, though not common, Australian species, occurring also in the Gulf of Florida, and *Retepora tubulata* (Busk), dredged by the "Challenger" naturalists off Cape York. Of these new species one, *Retepora Worsleyi*, is especially interesting, as it consists of narrow, dichotomously-divided branches, without any attempt at the formation of fenestræ. Mr. Hincks states (*British Marine Polyzoa*, page 389) that he is acquainted with a non-fenestrate *Retepore*, probably from the Red Sea; but, so far as I am aware, no description has yet been published.

Family CELLULARIIDÆ.

Scrupocellaria annectens, n. sp. Plate II., fig. 1.

Zoarium erect, branches narrow, dichotomously divided, nearly in the same plane. Zoœcia elongated, smooth; aperture elliptical, occupying about three-fourths of the front; margins thickened; an acute spine internally towards the upper extremity, below which is, in the fertile zoœcia, a clavate scutum, with a long slender pedicle arching over the aperture; ordinary zoœcia destitute of scuta; a zoœcium in the angle of bifurcation of a branch, with three short, slender spines superiorly. Oœcia broadly galeate, with a smooth rim inferiorly, and superiorly with several marginal or sub-marginal puncta, or foramina. A small, sessile, lateral avicularium, opening directly upwards at each external upper angle; a sessile avicularium, with acute mandible and usually serrated rostrum below the aperture of each zoœcium internally and near the mesian line. Posterior surface finely sulcate; a vibraculum at the base of each zoœcium, the seta very long, slender, and smooth; frequently a radical fibre or tube from the base of the vibraculum extending laterally to terminate in a similar situation in an opposite branch; a single vibraculum in the angle of bifurcation of a branch.

This species approaches the genus *Canda* in the manner in which the anterior avicularia are arranged, coming very near the mesian line, although not, as in that genus, placed on a special tract. In structure also they much resemble those of *Canda arachnoides*. The branches also are frequently connected by cross fibres or tubes attached to the bases of the vibracular cells. The scutum seems to be confined to the ovicelligerous zoœcia, and is wanting in the others.

There is usually a larger avicularium at the base of the zoœcium in a bifurcation. In the portion figured it is abnormal, being subcapitate, attached more to the side, and with a stout conical process growing from one side. It generally differs only from the ordinary form in its larger size.

Family RETEPORIDÆ.

Retepora Worsleyi, n. sp. Plate II., fig. 2.

Zoarium small, consisting of slender, dichotomously-divided branches. Zoœcia bi-triserial, smooth, or minutely granular, glassy; peristome produced, fluted, lower lip with a deep notch. In the lateral zoœcia the outer edge produced outwards, and having on its lower margin a sessile, horizontal avicularium, the rostrum terminated by two short, sharp teeth. Posterior surface strongly vibicate, finely granular, and glistening.

This species, which I have much pleasure in dedicating to Captain Worsley, differs from all the other described *Retepores*, in the complete absence of fenestræ or reticulation, the branches being very slender, dichotomously divided, and with no attempt at anastomosis. The peristome is largely produced, very distinct, and strongly fluted, with a deep mesian sinus. On the lateral zoœcia the outer part is produced in a fringed manner; and there is in the lower lip a horizontal sessile avicularium opening upwards, with the rostrum terminated by two short, sharp denticles, very much in the same manner as is seen in the fenestral avicularia of *R. serrata* (M'G.) Altogether the species is most interesting, as showing the inconstancy of zoarial as compared with zoœcial characters, even in a genus in which the zoarial character is usually so strongly marked.

Family IDMONEIDÆ.

Idmonea Gasparensis, n. sp. Plate II., fig. 3.

Zoarium small, dichotomously divided; zoœcia in irregular lines across the branches, usually a central, and one on each side, distinct, punctate; peristome long and projecting forwards, obscurely annulated or annularly and minutely punctate. Posterior surface longitudinally sulcate, and transversely and concentrically rugose; finely punctate; no calcified radical tubes.

This species presents the general structure of *I. Milneana*, D'Orb., and *I. interjuncta* (M'G.), but has very few zoœcia, only two or three in the diameter of a branch. The zoœcia are very long, distinct, and closely punctate, the puncta being elevated inflations, darker in the centre, and frequently perforated. The peristome, which is either annulated or with annular series of minute punctures, projects much forwards. The posterior surface is longitudinally sulcate, and concentrically ridged. There are none of the calcified bundles of radical tubes so characteristic of the other species mentioned.

EXPLANATION OF FIGURES.

PLATE I.

Fig. 1. *Lagenipora nitens.* Fig 1*a.* A few zoœcia, showing the primary mouths. Fig 1*b.* Mandible of vicarious avicularium.

Fig. 2. *Schizoporella rostrata,* two young zoœcia. Fig. 2*a.* Another portion of the same specimen, showing also oœcia.

Fig. 3. *Schizoporella pachnoides.* Fig. 3*a.* A single zoœcium from the same specimen.

Fig. 4. *Hornera ramosa,* natural size. Fig. 4*a.* Anterior surface magnified.

Fig. 5. *Lichenopora Wilsoni,* natural size. Fig. 5*a.* Section of same, to show height of zoœcia, magnified about two diameters. Fig. 5*b.* Small portion, showing part of central reticulation by fibres with spines; part of two series of zoœcia, and intervening cancelli.

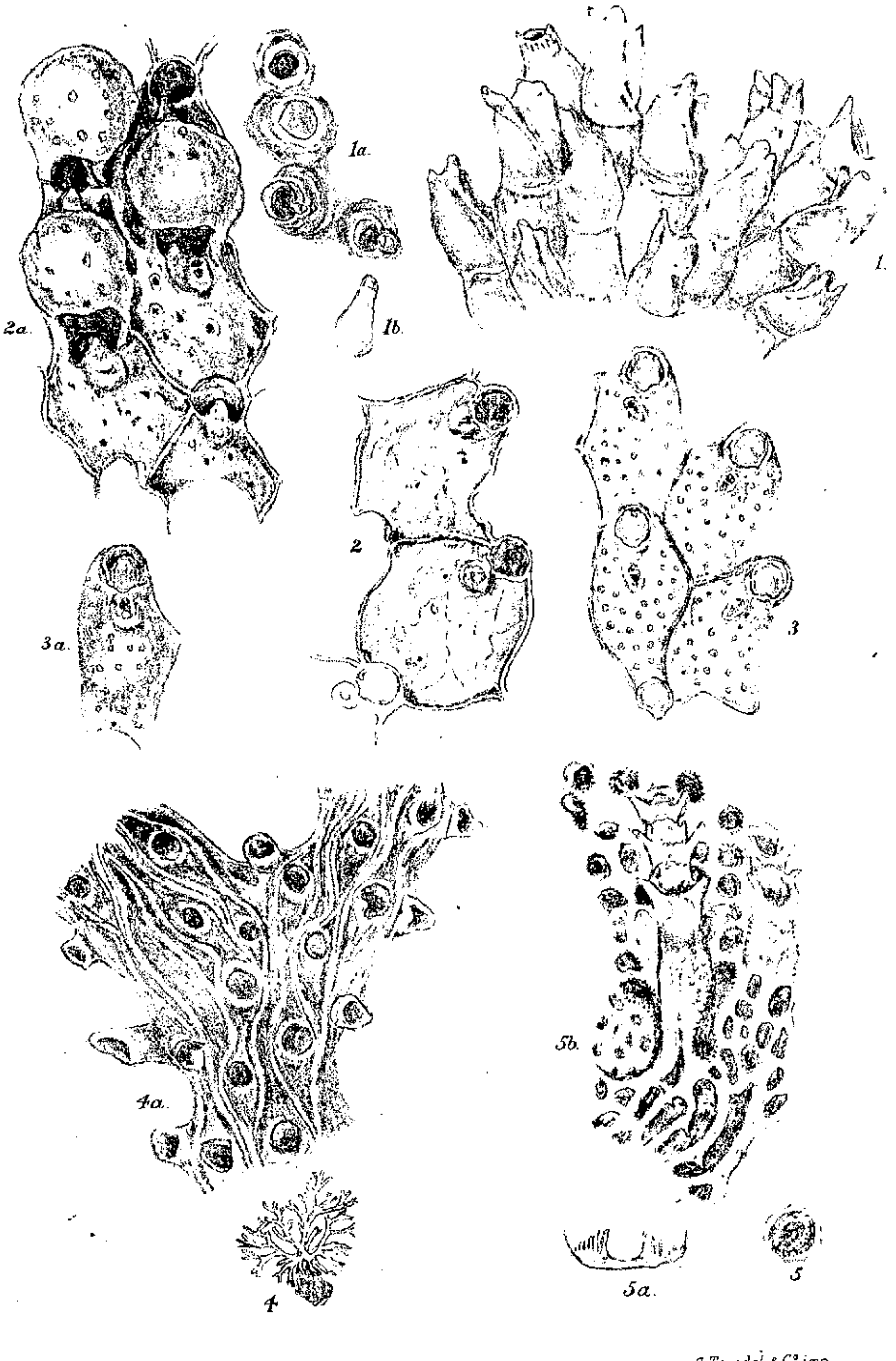
PLATE II.

Fig. 1. *Scrupocellaria annectens,* natural size. Fig. 1*a.* Anterior surface of branch magnified. Fig. 1*b.* Posterior aspect of same.

Fig. 2. *Retepora Worsleyi,* natural size. Fig. 2*a.* Anterior surface of branch magnified. Fig. 2*b.* Posterior aspect of same.

Fig. 3. *Idmonea Gasparensis,* natural size. Fig. 3*a.* Anterior surface magnified. Fig. 3*b.* Posterior surface.

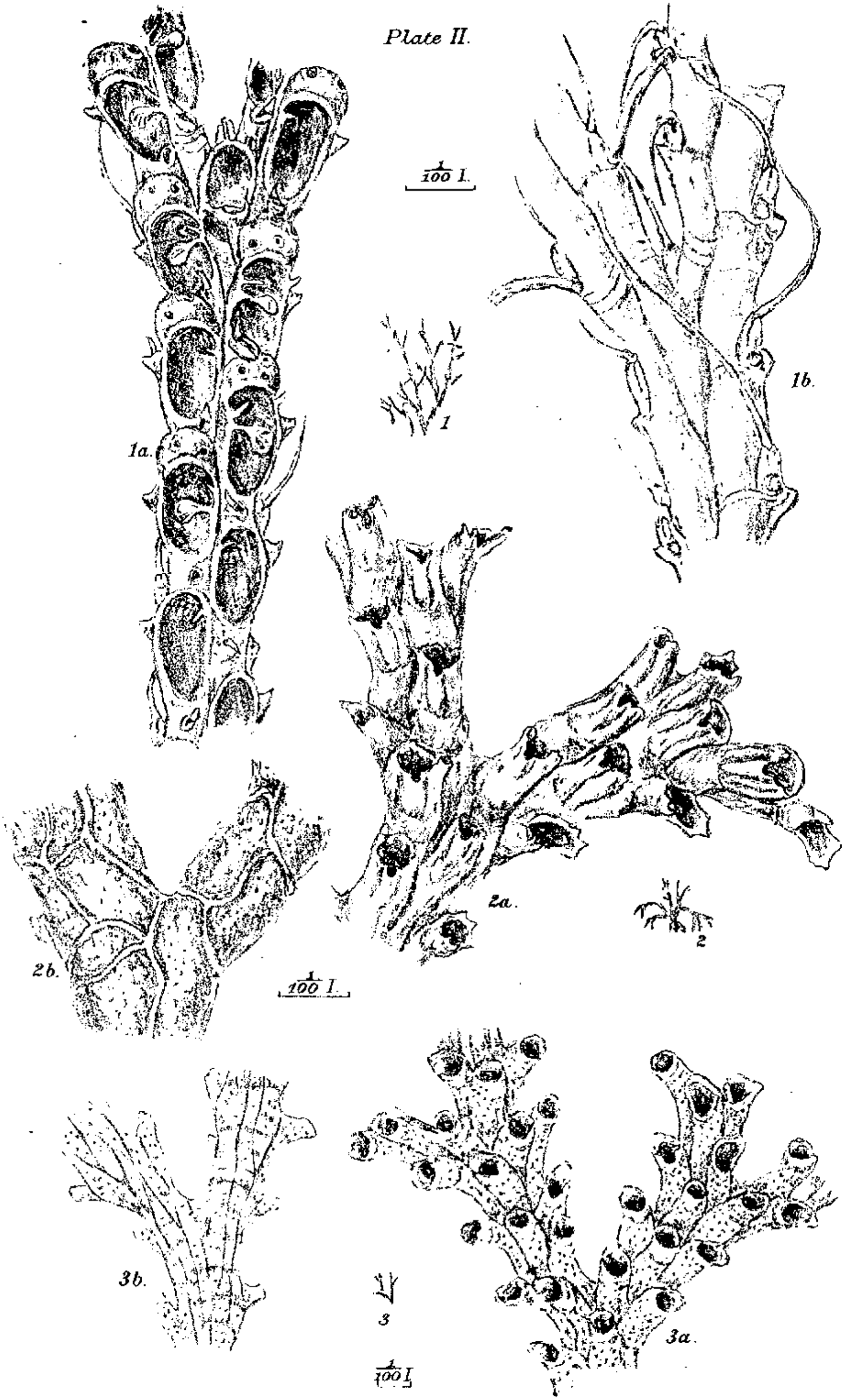
Plate I.



P. H. Mc G del & Lith.

C. Troedel & Co imp.

Plate II.



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Art. XVI.—*A Catalogue of the Marine Polyzoa of Victoria.*

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

[Read 11th November, 1886.]

As Professor M'Coy's "Prodromus of the Zoology of Victoria," in which I am fully describing and illustrating our Polyzoa, is unavoidably slow of publication, and as there are many observers interested in this department of our Fauna, I propose giving a list of all the marine species with which I am acquainted. To make it more useful, the characters of the families and genera, with references to the most readily available descriptions of the species, are given, and a bibliography of the more important works and papers on the subject is added.

In preparing this catalogue the materials I have had at my disposal have been specimens collected by myself in Hobson's Bay and at Port Phillip Heads, a collection made by Mr. H. Watts at Warrnambool and purchased for the National Museum, and others contributed by friends either to the Museum or to myself. I am, above all, indebted to my friend Mr. J. Bracebridge Wilson, for the generous liberality with which he has placed at my disposal large series of new and rare forms dredged at Port Phillip Heads and at Western Port, accompanied by much valuable information concerning them. His contributions to this and, I may add, to other branches of marine zoology as well as botany, have been invaluable, and without his aid, so freely given, this record could not have been nearly so extensive. Mr. Maplestone, for some time residing at Portland, has materially assisted me by the contribution of specimens, some previously undescribed. Baron von Mueller has kindly given me numerous specimens sent with algæ from various localities, and I have to thank other friends for their assistance.

Besides my colonial friends, I am under great obligations to Mr. Hincks and Mr. Waters for the kindness with which they have sent me many specimens for comparison, and to Miss Jelly for large series of specimens from Europe and other parts, which have been of great service.

The list, long as it is (including about 350 species), will certainly be very much added to. The only locality which has really been systematically searched is the neighbourhood of Port Phillip Heads, which has been dredged by Mr. Wilson and myself. Mr. Wilson has also spent some time dredging in Western Port, principally at the entrance, and Mr. Maplestone has dredged at Portland. The specimens from other localities have been collected on the beach.

It is hoped that the arrangement followed here will be found, at least, convenient.

For the classification of the Polyzoa all naturalists are now agreed that the zoœcial characters are of primary importance. At the same time, the zoarial, when constant, demand consideration, and in the Cyclostomata, owing to the little variety in the structure of the individual zoœcia, we are obliged to depend to a great extent on them. Of the zoœcial characters, among the Cheilostomata, the principal are the amount of calcification of the cell-wall, the presence or absence of special pores communicating with the body cavity, the form of the mouth (primary and secondary) with the structure of the operculum, the nature and situation of the oœcia, and the avicularia or vibracula. The form and structure of the mouth, including the operculum, undoubtedly afford one of the most constant and easily used means of diagnosis. The structure of the operculum, to the value of which attention was first drawn by Mr. Waters, has already proved of great assistance in the discrimination of the species of *Cellaria, Cellepora, Retepora* and other difficult genera, and there can be no doubt that much more use will be made of its characters than has hitherto been done. To the presence of special pores on the front of the zoœcia much importance must be attached. By special pores I mean the true pores found in the *Microporellidæ,* &c., opening directly into the body cavity. These are to be carefully distinguished from those which are formed by an outgrowth of the peristome on each side, overarching and meeting in the middle, leaving a pore opening into the peristomial cavity outside the true mouth, as in *Porina* and *Adeonella.* In old or highly calcified specimens of the latter genera it is often difficult or impossible to see the real structure, but in the growing edges the formation of this external or adventitious pore can be easily traced. It also occurs occasionally in species belonging to other genera, as in *Smittia Landsborovii*, var. *porinoides*. Of course both kinds of pore are essentially different and easily distinguished from the fenestræ or irregular perforations or depressions, caused by a deficiency in the calcification of the ectocyst, which contribute so much to the ornamentation of many species, and which are frequently filled or even heaped over with calcareous matter.

The division of the zoœcium into two cavities, as in *Steganoporella magnilabris, Chlidonia* and probably *Urceolipora*, is undoubtedly a difference of great importance, although we do not yet understand the real nature of this structure.

The oœcia deserve more attention than has hitherto been bestowed on them. There can be no doubt that their being internal and opening by a special pore, or external and superposed on zoœcia, or contained in or formed by modified zoœcia, are characters which ought to be considered of considerable importance in a natural classification.

The arrangement adopted sufficiently explains itself, but there are some points on which a few remarks may be advisable.

In the *Farciminariidæ* I have included Busk's *Farciminaria dichotoma* as *Verrucularia dichotoma*, taking the generic name proposed by Von Suhr, when he supposed it to be an alga. Mr. Hincks has referred it to *Flustrella* and there is no doubt that the structure of the mouth very much approaches that of the Ctenostomatous genus, and in fact it evidently forms one of the transitionary species between the two sub-orders. *Farciminaria* proper shews a decided approximation to the same, the presence of oœcia, however, and, in many species, of avicularia clearly placing it among the Cheilostomata; and I cannot but agree with Mr. Busk in considering that *Verrucularia* has more affinity with *Farciminaria* than with any other group. In any case, even if placed among the Ctenostomata, I do not see how it can be included in the genus Flustrella.

In the *Membraniporidæ* I have only included forms in which the operculum is incomplete, that is formed by a flap in the membranous front wall without a distinct articulation. The genus *Membranipora*, as defined in this paper, ought probably to be divided into two; those with the long, incurved spines and the zoœcium frequently prolonged below the area, might be separated as Gray's proposed genus

Callopora. Amphiblestrum, although a convenient genus, is not satisfactory. There is a wide difference, for instance, between *A punctigerum,* with only a minute portion of the corners of the area filled by a membranous thickening, and *A. argenteum* or *permunitum,* where a large portion is occupied by a calcareous lamina. It would probably be better to refer the latter forms to a distinct genus. I am a little doubtful about the propriety of my genus *Bathypora,* but the species is not easily referable to any of the other divisions.

In the *Microporidæ* I have included those Membraniporidan genera having the opercular valve complete and distinctly articulated. They are also all more or less calcareous in the front wall, beneath the generally thick epitheca with which they are covered.

To the *Microporellidæ* I have referred all the crustaceous or foliaceous, calcareous forms with distinct zoœcial pores. I cannot, however, agree with those authors who would place the *Adeona* group in the genus *Microporella* for the sole reason of the presence of one or more pores. The whole structure is evidently different, and, especially, the oœcia are not external but are modifications of ordinary zoœcia. The small articular processes on the aviculareau mandibles pointed out by Busk, although peculiar and strongly marked, are not altogether confined to the *Adeonæ,* but are still important in this connection as they do not seem to occur in the true *Microporellæ.* I am very much inclined to the view that the *Adeonæ* should take family rank. *Escharipora stellata* forms the transition between the two groups. In the Microporellidæ I also place the species which I originally described as *Lepralia magnirostris,* having overlooked the tubular zoœcial pore, and which has been referred to the genus *Porina* by Hincks. There has been much unnecessary confusion about this genus. It was proposed by D'Orbigny (" Paléontologie Française," V. 432) for erect bilaminate species with a special pore placed behind the mouth at the median or lateral part of the cell, and he took for his types, among living forms, *P. Africana* (D'Orb.), which he briefly defines, and *Eschara gracilis* of Milne Edwards. Now, the pore of *E. gracilis,* for which and its allies the generic name ought clearly to be retained, is external—*i.e.,* it is formed by the overarching and junction of processes of the peristome, and consequently communicates with the peristomial tube outside the true mouth. Mr. Waters has already pointed this out, and includes *E. gracilis* in *Porina*. The other species which Mr. Hincks refers to *Porina* ("British Marine Polyzoa," p. 229) certainly belong to the same genus as *E. gracilis*. The best known, *P. borealis*, was first described as an *Onchopora* by Busk, then made the type of a new genus—*Quadricellaria*—by Sars, and, that having been already used for a totally different set of species by D'Orbigny, was again referred to another new genus—*Tessaradoma*—by Norman. The last name is the one which, according to all the rules of nomenclature, ought to be adopted, notwithstanding that it is etymologically incorrect.

The large family of the *Escharidæ* I have arranged under three sub-families—*Schizoporellinæ*, equivalent to the *Myriozoidæ* of Hincks (whose name I do not adopt, as I am doubtful whether *Myriozoum* ought to be referred to the group), characterised by the plain mouth, with a sinus in the lower lip, and without any special development of the peristome; *Lepraliinæ*, where there is a plain semicircular or subcircular mouth without sinus or special peristome; and *Mucronellinæ*, distinguished by the growth of a distinct peristome developed in various ways. I had intended proposing a new genus for my *Eschara obliqua*, when Mr. Wilson informed me that it was mentioned under the appropriate name of *Parmularia* in a letter from Mr. Busk, and I have, therefore, adopted his MS name, although I am not aware that it has ever been published. In the *Mucronellinæ*, Busk's genus *Adeonella* is difficult to differentiate from *Porina*, unless it be that the lower lip of the primary mouth has a sinus, and of that, except in *A. dispar*, I am doubtful. The whole appearance is different, and in *Adeonella* the mandibles have the small articular processes pointed out by Busk.

In the catalogue I have throughout referred to my descriptions in Professor M'Coy's "Prodomus of the Zoology of Victoria," to the late Mr. Busk's "British Museum Catalogue" and "Polyzoa of the 'Challenger' Expedition," and to the "British Marine Polyzoa" of Mr. Hincks. The reference to the "Transactions of the Royal Society of Victoria" are to my own papers. In a considerable number of the references the species will be found under other generic names, especially in those belonging to the divisions of the old genera *Membranipora*, *Lepralia* and *Eschara*. No confusion however, need arise from this.

The following abbreviations are used :—

A.M.N.H.—"Annals and Magazine of Natural History."

B.M.C.—"British Museum Catalogue of Marine Polyzoa," by Mr. Busk.

B.M.P.—"British Marine Polyzoa," by Mr. Hincks.

C.P.—"'Challenger' Polyzoa," by Mr. Busk.

P.Z.V.—"Prodromus of Zoology of Victoria ;" "Polyzoa," by P. H. MacGillivray. The numbers refer to plates.

Q.J.M.S.—"Quarterly Journal of Microscopical Science."

T.R.S.V.—"Transactions of the Royal Society of Victoria."

C.M.—C. Maplestone.

H.W.—Henry Watts.

J.B.W.—J. Bracebridge Wilson.

The reference to friends (as J.B.W. and C.M. &c.) indicate that they were the first discoveries of the species which in many cases have not been found by other observers. With the exception of *Lepralia bifrons*, every species included in this catalogue has been examined by myself.

TABLE OF CLASSIFICATION.

Class. POLYZOA.

Sub-Class I. HOLOBRANCHIA, *Ray Lankester.*

Group A. Ectoprocta, *Nitsche.*

Order I. GYMNOLÆMATA, *Allman.*

(=Infundibulata, *Gervais*).

Sub-Order I. CHEILOSTOMATA, *Busk.*

Family. Aeteidæ.

Aetea, *Lamx.*

Family. Scrupariidæ.

Scruparia, *Oken.* | Dimetopia, *Busk.*

Family. Rhabdozoidæ.

Rhabdozoum, *Hincks.*

Family. Chlidoniidæ.

Chlidonia, *Sav.*

Family. CATENICELLIDÆ.

Catenicella, *Blainv.*
Claviporella, *M'G.*
Catenicellopsis, *J.B.W.*
Calpidium, *Busk.*

Family. CALWELLIIDÆ.

Calwellia, *Wyv. Thomson.*

Family. BIFAXARIIDÆ.

Urceolipora, *M'G.*

Family. CELLULARIIDÆ.

Cellularia, *Pallas.*
Maplestonia, *M'G.*
Scrupocellaria, *V. Beneden.*
Canda, *Lamx.*
Caberea, *Lamx.*
Amastigia, *Busk.*
Menipea, *Lamx.*
Didymia, *Busk.*
Nellia, *Gray.*
Farcimia, *Pourtales.*

Family. SALICORNARIIDÆ.

Cellaria, *Lamx.*

Family. TUBUCELLARIIDÆ.

Tubucellaria, *D'Orb.*

Family. BICELLARIIDÆ.

Bicellaria, *Blainv.*
Stirparia, *Goldstein.*
Bugula, *Oken.*
Beania, *Johnston.*

Family. FLUSTRIDÆ.

Flustra, *Linn.*
Carbasea, *Gray.*
Euthyris, *Hincks.*
Spiralaria, *Busk.*
Craspedozoum, *M'G.*

Family. FARCIMINARIIDÆ.

Farciminaria, *Busk.*
Verrucularia, *Von Suhr.*

Family. MEMBRANIPORIDÆ.

Pyripora, *D'Orb.*
Electra, *Lamx.*
Bathypora, *M'G.*
Membranipora, *Blainv.*
Amphiblestrum, *Gray.*
Biflustra, *D'Orb.*
Caleschara, *M'G.*

Family. MICROPORIDÆ.

Thairopora, *M'G.*
Diploporella, *M'G.*
Micropora, *Hincks.*

Family. STEGANOPORELLIDÆ.

Steganoporella, *Smitt.*

Family. CRIBRILINIDÆ.

Membraniporella, *Smitt.*	Hiantopora, *M'G.*
Cribrilina, *Gray.*	

Family. MICROPORELLIDÆ.

Microporella, *Gray.*	Adeona, *Lamx.*
Escharipora, *Smitt.*	Adeonellopsis, *M'G.*
Tessaradoma, *Norman.*	

Family. ESCHARIDÆ.

Sub-Family. Schizoporellinæ.

Schizoporella, *Hincks.*	Hippothoa, *Lamx.*
Parmularia, *Busk.*	Gemellipora, *Smitt.*

Sub-Family. Lepraliinæ.

Lepralia, *Johnston.*	Petralia, *M'G.*
Chorizopora, *Hincks.*	Cyclicopora, *Hincks.*

Sub-Family. Mucronellinæ.

Porella, *Gray.*	Mucronella, *Hincks.*
Smittia, *Hincks.*	Bracebridgia, *M'G.*
Adeonella, *Busk.*	Rhynchopora, *Hincks.*
Porina, *D'Orb.*	

Family. CELLEPORIDÆ.

Lagenipora, *Hincks.*	Pœcilopora, *M'G.*
Lekythopora, *M'G.*	Cellepora, *Fabricius.*

Family. RETEPORIDÆ.

Retepora, *Imperato.*

Family. SELENARIIDÆ.

Selenaria, *Busk.*

Sub-Order II. CYCLOSTOMATA, *Busk.*

Family. CRISIIDÆ.

Crisia, *Lamx.*

Family. IDMONEIDÆ.

Idmonea, *Lamx.*	Hornera, *Lamx.*

Family. TUBULIPORIDÆ.

Tubulipora, *Lamx.*	Liripora, *M'G.*
Stomatopora, *Bronn.*	Entalophora, *Lamx.*
Diastopora, *Johnston.*	

Family. DISCOPORELLIDÆ.

Lichenopora, *Defranc.*
Densipora, *M'G.*
Favosipora, *M'G.*
Flosculipora, *M'G.*

Family. FRONDIPORIDÆ.

Fasciculipora, *D'Orb.*

Sub-Order III. CTENOSTOMATA, *Busk.*

Family. FLUSTRELLIDÆ.

Flustrella, *Gray.*

Family. VESICULARIIDÆ.

Amathia, *Lamx.*

Group B. Entoprocta, *Nitsche.*

Order II. **PEDICELLINEA**, *Gervais.*

Family. PEDICELLINIDÆ.

Pedicellina, *Sav.*
Pedicellinopsis, *Hincks.*

Class. POLYZOA, *J. V. Thompson.*

(= Bryozoa, Ehrenberg.)

Sub-Class I. HOLOBRANCHIA, *Ray Lankester.*

Group A. Ectoprocta, *Nitsche.*

Order I. **GYMNOLÆMATA**, *Allman.*

(= Infundibulata, *Gervais.*)

Sub-Order I. CHEILOSTOMATA, *Busk.*

Family. AETEIDÆ.

Zoœcia arising from a creeping or free stolon, which is dilated at intervals, tubular, with a subterminal membranous area. No avicularia or oœcia.

Aetea, *Lamouroux.*

The only genus.

A. anguina, *Linn. sp.* B.M.C., Part I., p. 31; B.M.P., p. 4; C.P., p. 2.
A. recta, *Hincks.* B.M.P., p. 6.
A. dilatata, *Busk.* B.M.C., p. 31.

Family. Eucrateidæ.

Zoarium erect, free, phytoid. Zoœcia uni- or biserial, enlarged upwards, and with an oblique, subterminal, membranous area. No avicularia.

Scruparia, *Oken.*

Zoarium composed of tufts springing from a creeping, adherent base; branches originating from the front of a zoœcium below the area. Each zoœcium arising from that below by an articulated tube at the upper and posterior part.

S. chelata, *Linn. sp.* B.M.C., Part I., p. 29; B.M.P., p. 14; C.P., p. 3.

Dimetopia, *Busk.*

Zoœcia arranged in pairs united back to back, each pair looking at right angles to that below; at a bifurcation the zoœcia of a pair disjunct, and each giving rise to the first pair of a branch.

D. spicata, *Busk.* B.M.C., Part I., p. 35; P.Z.V., 46.

D. cornuta, *Busk.* B.M.C., Part I., p. 35; P.Z.V., 46; C.P., p. 47.

D. hirsuta, *M'G.* T.R.S.V., Nov., 1885.
Port Phillip Heads, J.B.W.

Family. Rhabdozoidæ.

Zoarium phytoid, erect; branches consisting of zoœcia arranged around an imaginary axis, the base of each branch terminating in a chitinous rod (modified radical fibre), the various rods uniting to form a stem. Zoœcia in linear series, each arising from the upper and back part of the one below; an oblique, membranous area above. Avicularia sessile or subcapitate, below the area, or replaced by articulated spines. Oœcia superior, galeate.

Rhabdozoum, *Hincks.*

The only genus.

R. Wilsoni, *Hincks.* A.M.N.H., Aug., 1882.
Port Phillip Heads, J.B.W.

Family. Chlidoniidæ.

Zoarium consisting of phytoid, erect tufts, arising from a creeping stolon; each tuft formed of chain-like series of zoœcia, rising from the lateral branches of an erect segmented stem. Zoœcia two-chambered, all facing the same way. Oœcia inflations of ordinary zoœcia.

Chlidonia, *Savigny.*

The only genus.

C. Cordieri, *Audouin sp.* C.P., p. 8; P.Z.V., 108.
(= Cothurnicella dædala, *W.T.*, = Chlidonia dædala, *M'G.*)

Family. CATENICELLIDÆ.

Zoarium phytoid, erect, branched, segmented, each internode consisting of a single zoœcium or of two or three united laterally (except rarely in ovicelligerous cells). Zoœcia all facing the same way, front entirely calcareous or membrano-calcareous; mouth situated at the upper part.

Catenicella, *Blainville.*

Branches originating from the summits of each of a geminate pair, or rarely from the sides of ordinary zoœcia. Zoœcia in single series, but at a bifurcation geminate, or each internode consisting of a geminate pair; mouth with simple margins, straight or hollowed and entire below, or with a small rounded notch.

a. Fenestratæ.

C. lorica, *Busk.* B.M.C., Part I., p. 6; P.Z.V., 24; C.P., p. 10.
C. ventricosa, *Busk.* B.M.C., Part I., p. 7; P.Z.V., 24; C.P., p. 10.
C. urnula, *M'G.* T.R.S.V., March, 1886.
Port Phillip Heads, J.B.W.
C. hastata, *Busk.* B.M.C., Part I., p. 7; P.Z.V., 24; C.P., p. 10.
C. alata, *Wyv. Thomson.* P.Z.V., 24.
C. gemella, *M'G.* T.R.S.V., July, 1886.
Port Phillip Heads, J.B.W.
C. amphora, *Busk.* B.M.C., Part I., p. 8; P.Z.V., 89; J.B.W.
C. plagiostoma, *Busk.* B.M.C., Part I., p. 8; P.Z.V., 24; C.P., p. 11.
Var. **setosa.**
C. intermedia, *M'G.* P.Z.V., 24.
C. cribraria, *Busk.* B.M.C., Part I., p. 9; P.Z.V., 24; C.P., p. 11.
C. rufa, *M'G.* P.Z.V., 24.
C. margaritacea, *Busk.* B.M.C., Part I., p. 9; P.Z.V., 24.
C. Wilsoni, *M'G.* P.Z.V., 89; J.B.W.
C. pulchella, *Maplestone.* P.Z.V., 89; C.P., p. 13; C.M.

b. Vittatæ.

C. formosa, *Busk.* B.M.C., Part I., p. 9.; P.Z.V., 24.
C. Hannafordi, *M'G.* P.Z.V., 24.
C. perforata, *Busk.* B.M.C., Part I., p. 10; P.Z.V., 24.
C. gracilenta, *M'G.* T.R.S.V., Nov., 1884.
Port Phillip Heads, J.B.W.
C. cornuta, *Busk.* B.M.C., Part I., p. 11; P.Z.V., 24 and 90.
C. ringens, *Busk.* B.M.C., Part I., p. 10.
Port Phillip Heads.
C. elegans, *Busk.* B.M.C., Part I., p. 10; P.Z.V., 24; C.P., p. 12.
C. Dawsoni, *Wyv. Thomson.* Dub. Nat. Hist. Rev., 1858.
C. Buskii, *Wyv. Thomson.* Dub. Nat. Hist. Rev., 1858; P.Z.V., 24.
C. venusta, *M'G.* T.R.S.V., March, 1886.
Port Phillip Heads, J.B.W.
C. fusca, *M'G.* P.Z.V., 90.

C. crystallina, *Wyv. Thomson.* P.Z.V., 24.
C. utriculus, *M'G.* P.Z.V., 89; H.W.
C. umbonata, *Busk.* B.M.C., Part I., p. 11; P.Z.V., 90; C.P., p. 13.
C. delicatula, *J.B.W. sp.* P.Z.V., 107; J.B.W.
(= Catenicellopsis delicatula).

c. Carinatæ.

C. carinata, *Busk.* B.M.C., Part I., p. 12; P.Z.V., 24.

Claviporella, *M'G.*

Branches springing usually from the summits of the zoœcia of a geminate pair, but occasionally from the sides of single zoœcia. Zoœcia single or geminate; usually a large lateral process on each side above, supporting a large, gaping avicularium, occasionally small, altered, or aborted; mouth narrow, arched above, contracted below, and extending downwards as a deep notch, giving the whole a key-hole appearance; usually several blunt, hollow processes above and to the sides of the mouth.

C. aurita, *Busk sp.* B.M.C., Part I., p. 8; P.Z.V., 24.
C. imperforata, *M'G.* T.R.S.V., July, 1886.
C. pulchra, *M'G.* T.R.S.V., July, 1886.
Port Phillip Heads, J.B.W.
C. geminata, *Wyv. Thomson sp.* P.Z.V., 24.

Catenicellopsis, *J. B. Wilson.*

Zoarium forming (usually) dichotomously divided, uniserial branches. Zoœcia arising from the upper and back part or from the sides of other zoœcia; those at a bifurcation geminate and giving rise to two other branches, or a single zoœcium giving rise to the first of a series from its side; mouth straight and entire below, arched above, having a stout lateral process on each side, with a small avicularium at the base externally and one or more hollow, blunt processes superiorly. Oœcium immersed in the uppermost zoœcium of a triplet.

C. pusilla, *J.B.W.* P.Z.V., 107.

Calpidium, *Busk.*

Each internode consisting of a single zoœcium, or of a median primary zoœcium and a lateral zoœcium, on one or both sides, united side to side with it; mouth contracted about the junction of the middle with the lower third, its upper margin very prominent and forming a hooded projection. An avicularium on each upper angle of an internode.

C. ponderosum, *Goldstein, sp.* P.Z.V., 107.
C. ornatum, *Busk.* B.M.C., Part I., p. 15; P.Z.V., 108.

Family. CALWELLIIDÆ.

Zoarium phytoid, erect, continuous. Zoœcia in pairs joined back to back, those of each pair connected by tubes with those of the next pair but one below; mouth terminal, opening upwards; at a bifurcation each zoœcium giving rise to a pair and a new series intercalated into the branches, starting by a pair of zoœcia. Oœcia superior.

Calwellia, *Wyv. Thomson.*

Zoœcial pairs arranged at right angles to those above and below.

C. bicornis, *Wyv. Thomson.* P.Z.V., 46.

C. gracilis, *Maplestone.* T.R.S.V., Nov., 1885.
Portland, C.M.; Port Phillip Heads, J.B.W.

Family. BIFAXARIIDÆ.

Zoarium phytoid, erect, continuous, or articulated. Zoœcia alternate, in two series united back to back and facing opposite ways; mouth terminal, opening directly or obliquely upwards.

Urceolipora, *M'G.*

(= Calymmophora, *Busk.*)

Zoarium continuous, irregularly branched. Zoœcia springing from the upper and posterior part of those immediately below; a slight ridge on each side, probably indicating a shallow, anterior chamber. Oœcium superior, embedded in the front of the zoœcium above.

U. nana, *M'G.* P.Z.V., 105.

U. dentata, *M'G.* P.Z.V., 105.
(= C. lucida, C.P., p. 83.)

Family. CELLULARIIDÆ.

Zoarium erect, branched, continuous, or articulated. Zoœcia all facing the same way, in single or multiple series, or in pairs, or arranged around an imaginary axis; partly or wholly open, and membranous in front. Avicularia, when present, sessile.

Cellularia, *Pallas.*

Zoarium articulated. Zoœcia biserial, oblong or rhomboidal, contiguous, usually perforated behind. Avicularia usually absent.

C. cuspidata, *Busk.* B.M.C., Part I., p. 19; P.Z.V., 58; C.P., p. 17.

Maplestonia, *M'G.*

Zoarium articulated, dichotomously or irregularly branched, joints annulated. Zoœcia uniserial or geminate, imperforate behind. No avicularia or vibracula.

M. cirrata, *M'G.* P.Z.V., 106. C.M. and J.B.W.

M. simplex, *M'G.* T.R.S.V., Nov., 1884.
Port Phillip Heads, J.B.W.

Scrupocellaria, *Van Beneden.*

Zoarium articulated, dichotomously branched. Zoœcia biserial, quadrate, furnished with oral spines; a sessile avicularium at the upper and outer angle, and a vibraculum in a sinus on the outer and lower part behind.

S. cyclostoma, *Busk.* B.M.C., Part I., p. 24; P.Z.V., 126.
S. obtecta, *Haswell.* P.Z.V., 126; J.B.W.
S. scrupea, *Busk.* B.M.C., Part I., p. 24; P.Z.V., 126.
S. cervicornis, *Busk.* B.M.C., Part I., p. 24; P.Z.V., 126.
S. ornithorhynchus, *Wyv. Thomson.* P.Z.V., 126; C.P., p. 24.
S. reptans, *Linn. sp.* B.M.C., Part I., p. 27; B.M.P., p. 52.
Port Phillip Heads, J.B.W.

Canda, *Lamouroux.*

Zoarium dichotomously branched; branches articulated, biserial, connected by transverse chitinous tubes attached at either end to a vibraculum. Avicularia large, situated on a special tract, on the front of the branches, between the rows of zoœcia. Each zoœcium with a vibraculum posteriorly.

C. arachnoides, *Lamx.* B.M.C., Part I., p. 26; C.P., p. 25.
C. tenuis, *M'G.* T.R.S.V., Nov., 1884.

Caberea, *Lamouroux.*

Zoarium continuous or imperfectly jointed, dichotomously branched. Zoœcia bi-multiserial, quadrate. Avicularia, when present, sessile on the outer side or front of the zoœcia. Vibracula large, on the back of the branches, biserial, each common to several zoœcia.

C. rudis, *Busk.* B.M.C., Part I., p. 37.
(= Menipea marginata, *Hincks.* A.M.N.H., Oct., 1884.)
C. grandis, *Hincks.* A.M.N.H., July, 1881.
C. Darwinii, *Busk.* C.P., p. 29; T.R.S.V., Nov., 1885.
C. glabra, *M'G.* T.R.S.V., Nov., 1885.

Amastigia, *Busk.*

Zoarium continuous, dichotomously branched. Zoœcia bi-multiserial. Sessile avicularia on the sides of the lateral zoœcia and in front. No vibracula, but avicularia on the back of the zoarium, one to several zoœcia, the mandible pointing downwards and inwards.

A. nuda, *Busk.* B.M.C., Part I., p. 40.
Port Phillip Heads, J.B.W.

Menipea, *Lamouroux.*

(Including Emma, *Gray,* and *Busk.*)

Zoarium articulated or (in one species) continuous. Zoœcia bi-multiserial, oblong, imperforate behind. A sessile, lateral avicularium (frequently absent), and one or two sessile avicularia (also frequently absent) on the front of the zoœcia. No vibracula.

M. cyathus, *W. Thomson.* P.Z.V., 58.
M. Buskii, *Wyv. Thomson.* P.Z.V., 58.

M. crystallina, *Busk sp.* B.M.C., Part I., p. 28; P.Z.V., 58; C.P., p. 23.

M. cervicornis, *M'G.* P.Z.V., 58.

M. tricellata, *Busk sp.* B.M.C., p. 28; P.Z.V., 58.

M. funiculata, *M'G.* T.R.S.V., Nov., 1885.

Didymia, *Busk.*

Zoarium articulated, each internode consisting of a pair of zoœcia united side to side. Zoœcia all facing the same way; aperture large, occupying the whole anterior surface; at a bifurcation the zoœcia not disjunct, and each giving origin to a pair.

D. simplex, *Busk.* B.M.C., Part I, p. 35; P.Z.V., 46.

Nellia, *Gray.*

Zoarium erect, articulated, branched. Zoœcia quadriserial, front flat or convex at the bottom, with raised margins and large aperture, filled in by a membrane.

N. oculata, *Busk.* B.M.C., Part I., page 18; P.Z.V., 49.

N. simplex, *Busk.* B.M.C., Part I., p. 19.
Port Phillip Heads.

Farcimia, *Pourtales.*

Zoarium calcareous, erect, branching; stems and branches composed of segments united by corneous joints. Zoœcia arranged in series round an imaginary axis, with elevated margins and depressed area, which is more or less covered in with membrane.

F. appendiculata, *Hincks.* A.M.N.H., March, 1883.
Port Phillip Heads, J.B.W.

Family. SALICORNARIIDÆ.

Zoarium erect, simple, branched, cylindrical, with the zoœcia arranged around an imaginary axis, or lobed and bilaminated. Zoœcia separated by raised margins, with a depressed surface. Oœcia immersed.

Cellaria, *Lamx.*

(= Salicornaria, *Cuv.*, *Busk*, &c.)

Zoarium simple or branched, cylindrical, with the zoœcia arranged around an imaginary axis.

C. Australis, *M'G.* P.Z.V., 49; T.R.S.V., 1884.
(= Salicornaria clavata, *Busk.* C.P., p. 83.)

C. rigida, *M'G.* P.Z.V., 105.
(= S. simplex, *Busk.* C.P., p. 88.)

C. hirsuta, *M'G.* P.Z.V., 49.

C. gracilis, *Busk.* B.M.C., Part I., p. 17; P.Z.V., 49; C.P., p. 93.

C. tenuirostris, *Busk.* B.M.C., Part I., p. 17; P.Z.V., 49 ? ; C.P., p. 92.

C. divaricata, *Busk.* C.P., p. 90.

C. bicornis, *Busk.* C.P., p. 90.
Port Phillip Heads, J.B.W.

Family. Tubucellariidæ.

Zoarium erect, branched; branches cylindrical. Zoœcia arranged around an imaginary axis, convex, distinct; mouth produced into a tubular peristome. No avicularia. Oœcia?

Tubucellaria, *D'Orbigny.*

Zoarium consisting of cylindrical internodes, connected by corneous tubes. Zoœcia ventricose above and attenuated downwards; usually a simple, circular, median pore; surface punctate or reticulo-scrobiculate.

T. hirsuta, *Busk sp.* P.Z.V., 49; C.P., p. 100.

T. cereoides, *Ellis* and *Solander.* P.Z.V., 105.
Port Phillip, S. Channel, J.B.W.

Family. Bicellariidæ.

Zoarium phytoid, erect and continuous, or adnate. Zoœcia continuous, loosely united or disjunct, and connected by corneous tubes, obconic or boat-shaped, wholly or partly open in front. Avicularia, when present, pedunculate, capitate, altered in form or aborted.

Bicellaria, *Blainville.*

Zoarium phytoid, erect, branches continuously celluliferous. Zoœcia biserial, obconic or turbinate, more or less free above and attenuated below; aperture directed upwards and forwards, with several articulated marginal or sub-marginal spines.

B. tuba, *Busk.* B.M.C., Part I., p. 42; P.Z.V., 59.

B. grandis, *Busk.* B.M.C., Part I., p. 42; P.Z.V., 59.

B. ciliata, *Linn. sp.* B.M.C., Part I., p. 42; B.M.P., p. 68; P.Z.V., 59.
Hobson's Bay.

B. gracilis, *Busk.* B.M.C., Part I., p. 42.
Port Phillip Heads, J.B.W.

B. turbinata, *M'G.* P.Z.V., 59.

Stirparia, *Goldstein.*

Zoarium consisting of tufts of celluliferous branches attached to bare annulated or segmented stems. Zoœcia biserial, turbinate; aperture looking upwards and forwards, and with marginal spines.

S. annulata, *Maplestone sp.* P.Z.V., 59.

S. glabra, *Hincks.* A.M.N.H., March, 1883; C.P., p. 35.
Lorne, *Mr. Wooster.*

Bugula, *Oken.*

Zoœcia bi-multiserial, closely contiguous, aperture very large, directed forwards, the margin not at all or very slightly thickened. Avicularia capitate, pedunculated, and articulated.

B. cucullata, *Busk.* P.Z.V., 78.

B. dentata, *Lamx.* B.M.C., Part I., p. 46; P.Z.V., 78.

B. neritina, *Linn. sp.* B.M.C., Part I., p. 44; P.Z.V., 59; C.P., p. 42.

B. robusta, *M'G.* P.Z.V., 78.

B. avicularia, *Pallas.* B.M.C., Part I., p. 45; P.Z.V., 78; B.M.P., p. 75.

Beania, *Johnston.*

(including Diachoris, *Busk.*)

Zoarium creeping or loosely adnate. Zoœcia disjunct, connected by (usually) corneous tubes, erect or decumbent, ovate or boat-shaped, entirely open in front and filled in by a thin membrane. Usually a capitate, pedunculate avicularium, perfect, aborted, or altered in form, on one or both sides towards the upper extremity (in some species absent).

B. mirabilis, *Johnston.* B.M.C., Part I., p. 32; B.M.P., p. 96; P.Z.V., 116.
Port Phillip Heads, J.B.W.

B. decumbens, *M'G.* P.Z.V., 117.
Port Phillip Heads, J.B.W.

B. Magellanica, *Busk.* B.M.C., Part I., p. 54; P.Z.V., 46; C.P., 59.

B. crotali, *Busk.* B.M.C., Part I., p. 54; P.Z.V., 46; C.P., p. 59.

B. Wilsoni, *M'G.* T.R.S.V., Nov., 1884.
Port Phillip Heads, J.B.W.

B. spinigera, *M'G.* P.Z.V., 46.

B. costata, *Busk.* P.Z.V., 117; C.P. 60.

B. conferta, *M'G.* T.R.S.V., Nov., 1885.
Port Phillip Heads, J.B.W. Portland, C.M.

B. intermedia, *Hincks sp.* A.M.N.H., Aug., 1881.
Port Phillip Heads, J.B.W.

B. radicifera, *Hincks sp.* P.Z.V., 117.

Family. FLUSTRIDÆ.

Zoarium expanded, flexible, calcareo-membranous, erect, foliaceous, ligulate, or spirally twisted round an imaginary axis. Zoœcia elongated, separated by raised margins; front entirely membranous or partially filled in by a thickened membrane.

Flustra, *Linn.*

Zoarium erect, foliaceous or ligulate. Zoœcia quadrate, entirely membranous in front, disposed in two layers facing opposite ways; operculum incomplete. Oœcia immersed.

F. denticulata, *Busk.* B.M.C., Part I., p. 49; P.Z.V., 45; C.P., p. 55.

Carbasea, *Gray.*

Zoarium erect, expanded, foliaceous or ligulate. Zoœcia entirely membranous in front, disposed in a single layer; operculum incomplete. Oœcia external, prominent.

C. dissimilis, *Busk.* B.M.C., Part I., p. 51; P.Z.V., 45; C.P., p. 56.
C. pisciformis, *Busk.* B.M.C., Part I., p. 50; P.Z.V., 45; C.P., 57.
C. indivi·a, *Busk.* B.M.C., Part I., p. 53; P.Z.V., 45.
Var. **cyathiformis,** *M'G.* P.Z.V., 45.
C. elegans, *Busk.* B.M.C., Part I., p. 53; P.Z.V., 45; C.P., p. 56.
C. (Flustra) reticulum, *Hincks.* A.M.N.H., Aug., 1882; T.R.S.V., Nov., 1884.
Port Phillip Heads, J.B.W.

Euthyris, *Hincks.*

(= Carbasea, part.)

Zoarium expanded, lobulate, erect. Zoœcia in a single layer; operculum complete, distinctly articulated. Oœcia external.
E. episcopalis, *Busk sp.* B.M.C., Part I., p. 52; P.Z.V., 45.

Spiralaria, *Busk.*

Zoarium a narrow, ribbon-shaped lamina, spirally twisted round an imaginary axis. Zoœcia entirely membranous in front, in a single layer, opening on the inner surface of the lamina.
S. florea, *Busk.* P.Z.V., 46.

Craspedozoum, *M'G.*

Zoarium erect, in ligulate divisions, uni- or bilaminate, each branch bordered throughout its whole extent by a bundle of radical fibres springing from the bases of the lateral zoœcia. Zoœcia quadrate, aperture partly filled in by a thickened lamina. Oœcia external.
C. roboratum, *Hincks sp.* A.M.N.H., Aug., 1881.
(= Membranipora roborata, *Hincks.*)
C. ligulatum, *M'G.* T.R.S.V., Nov., 1885.
C. spicatum, *M'G.* T.R.S.V., Nov., 1885.
Port Phillip Heads, J.B.W.

Family. Farciminariidæ.

Zoarium erect, branched, membranaceous or corneous; branches cylindrical or prismatic. Zoœcia distinct, arranged around an imaginary axis, almost entirely membranous in front; mouth incomplete, projecting.

Farciminaria, *Busk.*

Zoœcia oblong, elongated, closely contiguous, depressed in front, with raised margins; mouth close to the summit. Avicularia, when present, sessile or sub-immersed at the bottom or on the front of the zoœcia. Oœcia prominent, superior.
F. aculeata, *Busk.* B.M.C., Part I., p. 33.
F. uncinata, *Hincks.* A.M.N.H., Oct., 1884.
F. simplex, *M'G.* T.R.S.V., Nov., 1885.

Verrucularia, *von Suhr.*

Zoœcia elliptical or rounded, convex, bordered by a narrow, chitinous line, alternate in longitudinal series, separated laterally by an intercellular substance. Mouth a little below the summit. No avicularia. Oœcia ?

V. dichotoma, *Busk sp.* Q.J.M.S., N. Ser. I., 155.
(= Frustrella dichotoma, *Hincks.* A.M.N.H., May, 1884.)

Family. MEMBRANIPORIDÆ.

Zoarium encrusting, expanded, and continuous, or in branched single series, or erect in a single or double layer, membrano-calcareous. Zoœcia usually (not always) separated by raised margins; front entirely or partly occupied by a large area, which is wholly membranous or partially filled in by a thickened lamina. Operculum incomplete. Avicularia sessile or immersed.

Pyripora, *D'Orbigny.*

Zoarium adherent. Zoœcia distinct, thick, calcareous, convex, not separated by raised lines, narrowed below, in branched single series, or forming continuous expansions; a large oblique area in front, filled by a thin membrane.

P. catenularia, *Jameson sp.* B.M.C., Part I., p. 29; B.M.P., p. 134; P.Z.V., 106.

P. crassa, *M'G.* P.Z.V., 106.

P. polita, *Hincks.* P.Z.V., 106.

Electra, *Lamouroux.*

Zoarium encrusting, or filiform and erect, or foliaceous. Zoœcia elongated, narrow below, closely adherent together, lower part convex, covered with small discs or foraminate; area oval or rounded, occupying the whole width of the zoœcium above, deep, with thickened margins; one or more large whip-like spines (occasionally replaced by an avicularium) below the margin of the area, and a variable number of short, sharp spines on its circumference.

E. pilosa, *Linn. sp.* B.M.C., Part II., p. 56; B.M.P., p. 137; P.Z.V., 106.
(= Membranipora pilosa, Auctt.)

E. flagellum, *M'G.* P.Z.V., 106.
Port Phillip Heads, J.B.W.

Bathypora, *M'G.*

Zoarium encrusting. Zoœcia in longitudinal series, quadrate, separated by raised lines; lower part calcareous, convex, much projecting, smooth, and imperforate; area occupying the whole width of the upper part, deep, membranous, with a narrow, smooth lamina below.

B. nitens, *Hincks sp.* A.M.N.H., July, 1880.
(= **B. porcellana,** *M'G.* P.Z.V., 106. = Membranipora nitens, *Hincks.*)
Portland, C.M.

Membranipora, *Blainville.*

Zoarium encrusting. Zoœcia with the area occupying the whole front, or with part of the zoœcium produced below; area entirely membranous.

a. Front entirely occupied by the membranous area.

M. membranacea, *Linn. sp.* B.M.C., Part II., p. 56; P.Z.V., 25; B.M.P., p. 140.

M. serrata, *M'G.* P.Z.V., 127.

Var. **acifera,** *M'G.* P.Z.V., 127.

b. Zoœcium produced below the area; margin of area with a series of incurved spines.

(= Callopora, *Gray.*)

M. inarmata, *Hincks* P.Z.V., 127.

M. pecten, *M'G.* P.Z.V., 127.

M. pyrula, *Hincks.* P.Z.V., 127.

(= M. lineata, *M'G.* P.Z.V., 26.)

M. corbula, *Hincks.* P.Z.V., 127.

M. amplectens, *Hincks.* A.M.N.H., Aug., 1881.
Port Phillip Heads, J.B.W.

Amphiblestrum, *Gray.*

Zoarium encrusting. Zoœcia with the area occupying the whole front, or with part of the zoœcium produced below; area partly filled in below by an additional membranous or calcareous lamina.

a. Lamina membranous.

A. umbonatum, *Busk.* B.M.C., Part II., p. 57; P.Z.V., 26; C.P., p. 66.

A. cervicorne, *Busk.* B.M.C., Part II., p. 57; P.Z.V., 25; C.P., p. 66.

A. punctigerum, *Hincks sp.* P.Z.V., 106.

A. Flemingii, *Busk.* B.M.C., Part II., p. 58; B.M.P., p. 162; P.Z.V., 106.

A. spinosum, *Quoy and Gaimard?* P.Z.V., 127.

A. ciliatum, *M'G.* P.Z.V., 25 and 127.

A. albispinum, *M'G.* P.Z.V., 127.

A. bursarium, *M'G.* T.R.S.V., July, 1886.

(= A. Rosellii, *M'G.* P.Z.V., 26; T.R.S.V., Dec., 1881.)

b. Lamina Calcareous.

A. patellarium, *Moll. sp.?* P.Z.V., 117.

A. argenteum, *M'G.* T.R.S.V., Nov., 1886.

(= Lepralia trifolium, *M'G.* P.Z.V., 27)

A. permunitum, *Hincks.* P.Z.V., 106.

Biflustra, *D'Orbigny.*

Zoarium encrusting, or erect, foliaceous, and uni- or bilaminate. Zoœcia depressed, elongated, more or less quadrate, separated by much raised, highly calcified, usually crenulated margins; area partially filled in below and occasionally on the sides, by a calcareous, usually granulated, lamina, which generally slopes downwards from the margins.

B. delicatula, *Busk.* P.Z.V., 57.

B. perfragilis, *M'G.* P.Z.V., 57.

? **B. Lacroixii,** *Aud. sp.* B.M.C., Part II., p. 60; B.M.C., p. 129; P.Z.V., 26.

B. papulifera, *M'G.* P.Z.V., 106.
Port Phillip Heads, J.B.W.

B. bimamillata, *M'G.* P.Z.V., 106.
Portland, C.M.

Caleschara, *M'G.*

Zoarium encrusting, or erect, and uni- or bilaminate. Zoœcia separated by distinct, raised, calcareous margins; front covered by a thick epitheca, beneath which the calcareous front wall is bevelled to the depressed centre; on each side of the calcareous front is a longitudinal fissure, and across the upper part a thickened bar, leaving a membranous portion above containing the mouth, the operculum of which is incomplete. Oœcia altered and expanded zoœcia.

C. denticulata, *M'G.* P.Z.V., 48; C.P., p. 76.

Family. Microporidæ.

Zoarium encrusting or free and unilaminar. Zoœcia quadrate, separated by distinct, thick, raised margins; front depressed, calcareous, beneath a thick epitheca; operculum complete.

Thairopora, *M'G.*

(= Membranipora in part.)

Zoœcia quadrate, in transverse and linear series; surface uniform, but the sub-epithecal, calcareous lamina sometimes with a transverse fissure; chamber single; mouth straight; a stout, erect, unarticulated process on each side above. Avicularia replacing zoœcia.

T. dispar, *M'G.* P.Z.V., 26.

T. Woodsii, *M'G.* P.Z.V., 26.

T. mamillaris, *Lamk.* P.Z.V., 26.

T. armata, *M'G.* T.R.S.V., 1881.

T. Jervoisii, *Hincks sp.* T.R.S.V., July, 1886.
Sorrento, Rev. Dr. Porter.

Diploporella, *M'G.*

Zoœcia quadrate, divided into two parts, the anterior depressed, the posterior forming a box-like elevation; surface beneath the epitheca calcareous, perforated, and in the anterior portion with a transverse fissure; a stout, hollow, unarticulated, calcareous process on each side of the mouth. Avicularia replacing zoœcia.

D. cincta, *Hutton sp.* T.R.S.V., April, 1880.

Micropora, *Hincks.*

Zoœcia with the lower edge of the mouth thickened by a calcareous band; oral spines, when present, slender and articulated. Avicularia at the base of the zoœcia. Oœcia external, prominent.

M. perforata, *M'G.* P.Z.V., 25, 36.

M. coriacea, *Esper sp.* B.M.C., Part II., p. 57; B.M.P., p. 174.

Var. **angusta,** *M'G.* T.R.S.V., July, 1886.

Family. STEGANOPORELLIDÆ.

Zoarium encrusting or free and uni- or bilaminate. Zoœcia quadrate, arched above, separated by thick calcareous margins; divided into two chambers, an upper closed by the thick epitheca, and a lower separated by a perforated calcareous lamina and opening anteriorly by a tubular orifice. Oœcia altered zoœcia.

Steganoporella, *Smitt.*

The only genus.

S. magnilabris, *Busk sp.* B.M.C., Part II., p. 62; P.Z.V., 60; C.P., p. 75.

Family. CRIBRILINIDÆ.

Zoarium encrusting or erect, foliaceous, and unilaminar. Zoœcia contiguous or disjunct; front occupied by a series of ribs converging to a median line, and separated by grooves, which are either closed or perforated; or with variously arranged large, rounded, smooth-edged foramina.

Membraniporella, *Smitt.*

Zoarium adnate or foliaceous. Zoœcia contiguous or disjunct; front closed by a series of flattened, more or less consolidated, calcareous ribs.

M. distans, *M'G.* T.R.S.V., July, 1882.

Cribrilina, *Gray.*

Zoarium encrusting, or adnate or erect. Front of zoœcia with radiating furrows occupied by regular series of perforations, or irregularly pierced by large, more or less rounded, foramina; mouth semicircular or suborbicular, entire below.

C. radiata, *Moll. sp.* B.M.P., p. 185; C.P., p. 131.

C. setirostris, *M'G.* T.R.S.V., Oct., 1882.
Port Phillip Heads.

C. monoceros, *Busk.* B.M.C., Part II., p. 72; P.Z.V., 35.

C. acanthoceros, *M'G.* T.R.S.V., July, 1886.

Hiantopora, *M'G.*

Zoarium loosely adnate, attached by radical fibres. Zoœcia with the anterior surface occupied by irregular, rounded foramina; mouth sub-triangular, one or more sharp, calcareous denticles on one side, and on the lower edge of the peristome a large sessile avicularium, with the mandible opening upwards.

H. ferox, *M'G.* P.Z.V., 38.

Family. MICROPORELLIDÆ.

Zoarium encrusting or erect, and uni- or bilaminate. Zoœcia with the mouth entire below; front pierced by a single special pore or perforated plate, or by several pores, opening into the perivisceral cavity. Oœcia prominent and external, or modified zoœcia.

Microporella, *Gray.*

Mouth of zoœcium rounded, arched above, straight below; a single zoœcial pore or a perforated plate below the mouth. Oœcia external.

M. ciliata, *Linn. sp.* B.M.C., Part II., p. 72; P.Z.V., 37; B.M.P., p. 206; C.P., p. 138.

Var. **personata**, *Busk.* B.M.C., Part II., p. 74; C.P., p. 137; B.M.P., p. 207.

Var. **umbonata**, *M'G.* MSS.

M. diadema, *M'G.* P.Z.V., 37.

Var. **lunipuncta**, *M'G.* T.R.S.V., Nov., 1884.

Var. **lata**, *M'G.* T.R.S.V. Nov., 1884.

Var. **longispina**, *M'G.* T.R.S.V., Nov., 1884.

Var. **canaliculata**, *M'G.* T.R.S.V., Nov., 1884.
(= Lepralia canaliculata, *M'G.* P.Z.V.)

M. renipuncta, *M'G.* T.R.S.V., July, 1882.

M. Malusii, *Andouin sp.* B.M.C., Part II., p. 83; P.Z.V., 36; B.M.P., p. 211; C.P., p. 137.

Var. **thyreophora**, *Busk sp.* Q.J.M.Sc. V. 172.

Var. **umbonata**, *M'G.* MSS.

M. scandens, *M'G.* T.R.S.V., Nov., 1884.

Escharipora, *Smitt.*

Zoarium encrusting, mouth arched above, straight below; several stellate, zoœcial pores on the front of the zoœcia. Avicularian mandibles without projecting articular points.

E. stellata, *Smitt.* T.R.S.V., July, 1882.
Port Phillip Heads, J.B.W.

Tessaradoma, *Norman.*

(= Porina, *Hincks.*)

Zoarium encrusting or foliaceous and unilaminate, or erect and ramose. Zoœcium with the peristome produced and turned forward in a tubular or subtubular manner; a median tubular zoœcial pore.

T. magnirostris, *M'G.* T.R.S.V., July, 1882.

Adeona, *Lamx.*

Zoarium usually erect and bilaminate, continuous or fenestrate; attached by a slightly flexible stem, composed of radical tubes more or less calcified. Zoœcia with the mouth subcircular, and one or several clustered zoœcial pores. Oœcia modified zoœcia. Avicularian mandibles with projecting articular processes at the basal angles.

a. Continuous.

b. Fenestrate.

(= Dictyopora, *M'G.*)

A. cellulosa, *M'G.* P.Z.V., 47.
A. Wilsoni, *M'G.* P.Z.V., 66.
Port Phillip Heads, J.B.W.
A. albida, *Kirchenpauer.*
Var. **avicularis,** *M'G.* P.Z.V., 66; J.B.W.
A. grisea, *Lamx.* P.Z.V., 66; J.B.W.

Adeonellopsis, *M'G.*

Zoarium usually erect and bilaminate, continuous, attached by a rigid base. Zoœcia with the mouth subcircular. Oœcia altered zoœcia. Avicularian mandibles with projecting articular processes at the basal angles.

A. mucronata, *M'G.* P.Z.V., 48.
A. foliacea, *M'G.* T.R.S.V., Nov., 1885.
Western Port, J.B.W.
A. Australis, *M'G.* T.R.S.V., Nov., 1885.
A. parvipuncta, *M'G.* T.R.S.V., Nov., 1885.
A. latipuncta, *M'G.* T.R.S.V., Nov., 1885.

Family. ESCHARIDÆ.

Zoarium crustaceous, erect, and uni- or bilaminate or dendroid. Zoœcia entirely calcareous, horizontal, entire, or variously punctured, but without special pores opening into the perivisceral cavity. Oœcia external.

Sub-family. SCHIZOPORELLINÆ.

Lower lip with a distinct notch or sinus. No true peristome.

Schizoporella, *Hincks.*

Zoarium encrusting, or erect and foliaceous. Zoœcia closely adherent to each other.

S. Cecilii, *Audouin sp.* P.Z.V., 35; B.M.P., p. 269; C.P., p. 161.
S. schizostoma, *M'G.* P.Z.V., 38.
(= ? L. Kirchenpaueri, *Heller.*)
S. circinata, *M'G.* P.Z.V., 35.
S. Maplestoni, *M'G.* P.Z.V., 35; C.M.
S. vitrea, *M'G.* P.Z.V., 38.
(= also probably L. botryoides, *M'G.* P.Z.V., 38.)

S. triangula, *Hincks.* A.M.N.H., July, 1881; C.P., p. 167.
S. lata, *M'G.* T.R.S.V., July, 1882.
S. punctigera, *M'G.* T.R.S.V., July, 1883.
S. dædala, *M'G.* T.R.S.V., July, 1882, and Oct., 1886.
(= S. insignis *M'G.* non *Hincks* = S. controversa *Hincks, ? Waters.*)
S. arachnoides, *M'G.* T.R.S.V., Oct., 1882.
S. Ridleyi, *M'G.* T.R.S.V., Oct., 1862.
S. anceps, *M'G.* P.Z.V., 35.
S. latisinuata, *Hincks.* A.M.N.H., Aug., 1882.
Port Phillip Heads, J.B.W.
S. subsinuata, *Hincks.* A.M.N.H., Oct., 1884.
Port Phillip Heads, J.B.W.
S. pulcherrima, *M'G.* T.R.S.V., Nov., 1884.
S. biturrita, *Hincks.* A.M.N.H., Oct., 1884.
S. cryptostoma, *M'G.* T.R.S.V.
Port Phillip Heads. J.B.W.
S. Woosteri, *M'G.* T.R.S.V., July, 1886.
Queenscliff, Mr. Wooster.
S. hyalina, *Linn. sp.* B.M.C., Part II., p. 84; B.M.P., p. 271; C.P., p. 148.
S. pellucida, *M'G.* P.Z.V., 38.
(probably var. of preceding.)
S. rostrata, *M'G.* T.R.S.V., Nov., 1886.
Port Phillip Heads, J.B.W.
S. pachnoides, *M'G.* T.R.S.V., Nov., 1886.

Parmularia, *Busk, MSS.*

Zoarium foliaceous, bilaminate, attached by a large, flexible radical tube. Zoœcia oblique.

P. obliqua, *M'G. sp.* P.Z.V., 48.

Hippothoa, *Lamouroux.*

Zoarium adnate. Zœcia distant, connected by creeping tubes so as to form linear series, or partly clustered in small patches.

H. distans, *M'G.* T.R.S.V., 1868.
(= H. flagellum, *Manzoni.* B.M.P., p. 293; C.P., p. 4.)
H. divaricata, *Busk.* B.M.C., Part I., p. 30; C.P., p. 4.

Gemellipora, *Smitt.*

Zoarium crustaceous, or erect and ramose. Mouth horse-shoe shaped or pyriform, with a prominent denticle on each side for the articulation of the operculum; lower lip with a deep sinus.

G. striatula, *Sm.* T.R.S.V., July, 1882.

Sub-family. Lepraliinæ.

Lower lip of mouth entire; no special development of the peristome.

Lepralia, *Johnston.*

Zoarium encrusting or erect, and uni- or bilaminate. Zooecia closely adherent to each other; mouth horse-shoe shaped, usually slightly contracted at the sides; lower lip straight or slightly hollowed.

L. Pallasiana, *Moll.* B.M.C., Part II., p. 81; B.M.P., p. 297.
(= pertusa, P.Z.V., 36.)

L. pertusa, *Espar sp.* B.M.C., Part II., p. 80; B.M.P., p. 305.

L. elegans, *M'G.* P.Z.V., 36.

L. subimmersa, *M'G.* P.Z.V., 35.

L. quadrata, *M'G. sp.* P.Z.V., 48.

L. bifrons, *Hincks.* A.M.N.H., Oct., 1884. J.B.W.
Not seen by me.

L. setigera, *Smitt sp.* T.R.S.V., July, 1882.

Chorizopora, *Hincks.*

Zoarium encrusting. Zooecia elongated, more or less distant, and connected by a tubular network; mouth arched above, straight or hollowed below; each zooecium surmounted by an avicularium with the mandible directed upwards. Ooecia pyriform, with a small avicularium on the summit.

C. Brogniartii, *Audouin sp.* B.M.C., Part II., p. 65; B.M.P., p. 224; P.Z.V., 36; C.P., p. 148.

C. vittata, *M'G.* P.Z.V., 37.

Petralia, *M'G.*

Zoarium erect, foliaceous, stony, unilaminar, fenestrate. Zooecia horizontal, distinct throughout the entire thickness of the zoarium, and sharply defined behind; mouth nearly circular, with a sharp denticle on each side below.

P. undata, *M'G.* P.Z.V., 63.

Cyclicopora, *Hincks.*

Zoarium encrusting or loosely adnate. Zooecia elongated; mouth subcircular, turned forwards, with slightly thickened margin. Ooecia prominent.

C. longipora, *M'G. sp.* P.Z.V., 116.

Sub-family. Mucronellinæ.

Zooecia with the primary mouth entire or (Rhynchopora), with a sinus below; secondary mouth differing from the primary by the special development of the peristome.

Porella, *Gray.*

Primary mouth semi-circular; secondary mouth with a projection of the peristome below, within or on the edge of which is a small avicularium with a rounded mandible.

P. marsupium, *M'G. sp.* P.Z.V., 35; T.R.S.V., Oct., 1882; C.P., p. 147.

P. formosa, *M'G.* T.R.S.V., July, 1886.

P. concinna, *Busk sp.* B.M.C., Part II., p. 67; B.M.P., p. 323.

P. papulifera, *M'G.* P.Z.V.

(= ? P. rostrata, *Hincks* = Mucronella Serratirostris, *M'G.*)

Smittia, *Hincks.*

Primary mouth semicircular, with a square denticle on the lower margin; secondary mouth elongated, the peristome raised on the sides, and leaving a spout-like channel below, in which is usually lodged an avicularium.

S. Landsborovii, *Busk.* B.M.C., Part II., p. 66; B.M.P., p. 341.

Var. **porinoides,** *M'G.* MSS.

S. oculata, *M'G.* T.R.S.V., July, 1882; J.B.W.

S. marionensis, *Busk.* B.M.C., Part II., p. 67; C.P., p. 152.

S. trispinosa, *Johnston sp.* B.M.C., Part II., p. 70; B.M.P. p. 353.

Var. **bimucronata,** *Hincks.* A.M.N.H., May, 1884.

S. spathulata, *M'G.* T.R.S.V., July, 1882.

S. calceolus, *M'G.* T.R.S.V., July, 1886.

S. cribraria, *M'G.* T.R.S.V., Nov., 1885.

Adeonella, *Busk.*

Zoarium usually erect and bilaminate. Zoœcia distinct; primary mouth hollowed or sinuated below; peristome developing a process from each side below, the two meeting in the middle to leave a round, suboral foramen opening into the throat in front of the operculum. Oœcia modified zoœcia.

A. dispar, *M'G.* P.Z.V., 48.

A. platalea, *Busk.* B.M.C., Part II., p. 90; P.Z.V., 48; C.P., p. 184.

Porina, *D'Orbigny.*

Zoarium encrusting or erect and bilaminate. Zoœcia indistinct, primary mouth subcircular, peristome produced from each side and meeting in the front, leaving one or more suboral pores opening into the throat in front of the operculum.

P. gracilis, *M. Edwards sp.* B.M.C., Part II., p. 91; P.Z.V., 48; C.P., 141.

P. larvalis, *M'G.* P.Z.V., 37.

Mucronella, *Hincks.*

Primary mouth semicircular or suborbicular, secondary mouth with the peristome of the lower lip much elevated into a projecting mucro.

M. tricuspis, *Hincks.* P.Z.V., 116; C.P., p. 159.

Var. **munita,** *M'G.* P.Z.V., 116; J.B.W.

M. excavata, *M'G.* P.Z.V., 38; (probably var. *M. coccinea*).
M. vultur, *Hincks.* P.Z.V., 116.
M. Ellerii, *M'G.* P.Z.V., 37.
M. lævis, *M'G.* P.Z.V., 116; J.B.W.
M. diaphana, *M'G.* P.Z.V., 35.
M. papillifera, *M'G.* P.Z.V., 37.
M. avicularis, *M'G.* T.R.S.V., March, 1886; J.B.W.
M. spinosissima, *Hincks.* A.M.N.H., Aug., 1881.

Bracebridgia, *M'G.*

Zoarium encrusting, or erect and bilaminate. Mouth subcircular, with an internal denticle; peristome raised, thick, vicarious avicularia on the free margin of the branches, the triangular mandibles with a projecting articular process at each lower angle.
B. pyriformis, *Busk sp.* C.P., p 155; T.R.S.V., Nov., 1885.

Rhynchopora, *Hincks.*

Zoarium encrusting. Zoœcia closely adherent to each other. Primary mouth transversely elongated, with a sinus in the lower lip; secondary mouth with a prominent mucro on the lower margin, and an uncinate process immediately above it within the mouth.
R. bispinosa, *Johnston.* B.M.C., Part II., p. 77; B.M.P., p. 385.
R. longirostris, *Hincks.* A.M.N.H., Aug., 1881.
R. profunda, *M'G.* T.R.S.V., Oct., 1881; J.B.W.
(Probably a deeply calcified form of preceding.)

Family. Celleporidæ.

Zoarium encrusting or more or less free and uni- or bilaminate, or dendroid, or forming clustered masses. Zoœcia (adult) urceolate, irregularly heaped together, the upper parts being free; mouth terminal, sub-circular, or with a straight or hollowed lower lip, with or without a sinus.

Lagenipora, *Hincks.*

Zoarium encrusting. Zoœcia flask-shaped, mouth subcircular without a sinus.
L. tuberculata, *M'G.* T.R.S.V., July, 1882.
L. nitens, *M'G.* T.R.S.V., Oct., 1886.
Port Phillip Heads, J.B.W.

Lekythopora, *M'G.*

Zoœcia flask-shaped or elongated, oblique or erect and crowded; primary mouth with a deep notch in the lower lip, and a small avicularium at one side; secondary mouth with the peristome produced into a long, tubular orifice, on one side of the margin of which is the avicularium, connected with its original position by a minute semi-spiral tube. Oœcia projecting from the front of the zoœcia below the mouth, covered by a chitinous or subcalcareous plate.

L. hystrix, *M'G.* T.R.S.V., Oct., 1882, and Nov., 1884.

Pœcilopora, *M'G.*

Zoarium erect, bilaminate, branched. Zoœcia indistinct; primary mouth with a sinus; peristome commencing on an elevated point with a small avicularium on the summit, finally becoming a tumid, subcircular ring. Oœcia immersed, covered by a perforated plate.

P. anomala, *M'G.* T.R.S.V., Nov., 1885.
Port Phillip Heads, J.B.W.

Cellepora, *Fabricius.**

Zoarium crustaceous, adnate, or glomerulous, or foliaceous and partly free, or ramose. Zoœcia, in the crustaceous and foliaceous forms, erect and confused in the central parts, decumbent at the growing edges; one or more rostral processes, usually bearing avicularia, in the neighbourhood of the mouth (but sometimes absent), usually numerous other scattered avicularia of various forms, frequently raised on calcareous elevations.

C. hastigera, *Busk.* C.P., p. 192.
C. diadema, *M'G.* MSS.; J.B.W.
C. albirostris, *Smitt sp.* C.P., p. 193.
C. lirata, *M'G.* MSS.
C. fusca, *Busk.* B.M.C., Part II., p. 88.
C. prolifera, *M'G.* MSS.
C. foliata, *M'G.* MSS.
C. verrucosa, *M'G.* MSS.
C. spicata, *M'G.* MSS.
C. muscosa, *M'G.* MSS.
C. denticulata, *M'G.* MSS.
C. simplex, *M'G.* MSS.
C. intermedia, *M'G.* T.R.S.V., 1868.
C. bispinata, *Busk.* B.M.C., Part II., p. 87.
C. speciosa, *M'G.* P.Z.V., 128.
C. mamillata, *Busk.* B.M.C., Part II., p. 87.
C. cellulosa, *M'G.* MSS.
C. tridenticulata, *Busk.* P.Z.V., 128.
C. longirostris, *M'G.* T.R.S.V., Nov., 1884.
C. munita, *M'G.* T.R.S.V., Nov., 1884.
C. megasoma, *M'G.* T.R.S.V., Nov., 1884.
C. serratirostris, *M'G.* P.Z.V., 128.
C. costata, *M'G.* T.R.S.V., 1868.
C. rota, *M'G.* T.R.S.V., Nov., 1884.

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*The species of Cellepora which are distinguished only by MSS. names will be described in my next communication to the Society.

C. Costazii, *Audoiun.* T.R.S.V., Nov., 1884.
C. platalea, *M'G.* T.R.S.V., Nov., 1884.
C. glomerulata, *M'G.* MSS.
C. vitrea, *M'G.* MSS.; J.B.W.
C. tiara, *M'G.* MSS.; J.B.W.
C. benemunita, *M'G.* MSS.

Family. RETEPORIDÆ.

Zoarium calcareous, erect, foliaceous, reticulate or ramose, originating from a contracted base. Zoœcia oblique, closely united or immersed, indistinct posteriorly.

Retepora, *Imperato.*

Zoarium usually fenestrate or reticulate, rarely simply branched; posterior surface vibicate.
R. monilifera, *M'G.* P.Z.V., 94, 95, 96.
Form **sinuata,** *M'G.* 94, 96.
Form **munita,** *Hincks.*
Var. **lunata,** *M'G.* P.Z.V., 94, 96.
Var. **acutirostris,** *M'G.* P.Z.V., 94, 96.
Form **umbonata,** *M'G.* P.Z.V., 94, 97.
R. formosa, *M'G.* P.Z.V., 94, 97.
R. carinata, *M'G.* P.Z.V., 94, 96.
R. aurantiaca, *M'G.* P.Z.V., 94, 98.
R. tesselata, *Hincks.* P.Z.V., 94, 99.
R. serrata, *M'G.* P.Z.V., 94, 99.
R. granulata, *M'G.* P.Z.V., 94, 99.
R. porcellana, *M'G.* P.Z.V., 94, 95.
Var. **laxa,** *M'G.* P.Z.V., 94, 95.
R. phœnicea, *Busk.* B.M.C., Part II., p. 94; P.Z.V., 94, 98.
R. fissa, *M'G.* P.Z.V., 94, 95.
(= R. marsupiata, *Smitt.*)
R. avicularis, *M'G.* P.Z.V., 94, 95.

Family. SELENARIIDÆ.

Zoarium more or less regularly orbicular, convex on one side, plane or concave on the other, probably free. Furnished with large and powerful vibracula.

Selenaria, *Busk.*

Only a certain number of zoœcia dispersed throughout the zoarium furnished with vibracula. The front of each cell so furnished, covered by a cribriform, calcareous expansion; others arched above, contracted below; under surface of zoarium marked with grooves.
S. maculata, *Busk.* B.M.C., Part II., p. 101.
Port Phillip Heads, J.B.W.

Sub-Order II. CYCLOSTOMATA, *Busk.*

I. Articulata s. radicata.

Zoarium free, branched, divided into distinct internodes by flexible joints, attached by radical tubes. Zoœcia tubular, calcareous, in one or two series.

Family. Crisiidæ.

The only family.

Crisia, *Lamouroux.*

Two or more zoœcia in each internode, in two alternate series.

C. Edwardsiana, *D'Orb.* B.M.C., Part III., p. 5; P.Z.V., 39.
C. biciliata, *M'G.* P.Z.V., 39.
C. setosa, *M'G.* P.Z.V., 39.
C. tenuis, *M'G.* P.Z.V., 39.
C. acropora, *Busk.* B.M.C., Part III., p. 6; P.Z.V., 39.
C. margaritacea, *Busk.* B.M.C., Part III., p. 6.

II. Inarticulata.

Zoarium continuous, not divided into internodes, erect, adnate or encrusting; radical tubes, when present, multilocular and calcareous.

Family. Idmoneidæ.

Zoarium erect, branched, branches distinct or anastomosing. Zoœcia distinct, opening on one surface only.

Idmonea, *Lamouroux.*

Zoœcia arranged in parallel or subparallel rows, diverging from the mesial line.

I. radians, *M. Edwards.* B.M.C., Part III., p. 11; P.Z.V., 68.
I. Australis, *M'G.* P.Z.V., 68.
I. Atlantica, *E. Forbes.* B.M.C., Part III., p. 11; B.M.P., p. 451.
Port Phillip Heads, J.B.W.
Var. **tenuis,** *Busk.* B.M.C., Part III., p. 11.
Port Phillip Heads, J.B.W.
I. Milneana, *D'Orb.* B.M.C., Part III., p. 12.; P.Z.V., 68.
I. interjuncta, *M'G.* T.R.S.V., Nov., 1885.
Port Phillip Heads, J.B.W.

Hornera, *Lamouroux.*

Zoarium branched, branches distinct, anastomosing, or connected by transverse bars. Zoœcia distinct, opening irregularly on one surface.

H. ramosa, *M'G.* T.R.S.V., Nov., 1886.

H. robusta, *M'G.* P.Z.V., 118.
H. foliacea, *M'G.* B.M.C., Part III., p. 19 ; P.Z.V., 118.

Family. TUBULIPORIDÆ.

Zoarium encrusting or adnate, or partially or wholly erect ; when erect, bilaminate or cylindrical. Zoœcia tubular, when zoarium erect, opening on both sides. No intercellular cancelli. Oœcium an inflation of part of the zoarium.

Tubulipora, *Lamouroux.*

Zoarium adnate, irregularly shaped, frequently lobed or flabellate. Zoœcia elongated, tubular, distinct, partially free, arranged in more or less diverging series.
T. clavata, *M'G.* T.R.S.V., 1884.
T. serpens, *Linn. sp.* B.M.C, Part III., p. 25 ; B.M.P., p. 453.
T. connata, *M'G.* T.R.S.V., 1884.
T. pulchra, *M'G.* T.R.S.V., 1884.
T. lucida, *M'G.* T.R.S.V., Dec., 1884.
T. concinna, *M'G.* T.R.S.V., 1884.
T. corrugata, *M'G.* MSS.

Stomatopora, *Bronn.*

Zoarium adnate, simple or irregularly branched; branches linear or ligulate. Zoœcia in simple series or in more or less regular transverse rows.

(= Alecto.)

S. geminata, *M'G.* T.R.S.V., March, 1886.
Port Phillip Heads, J.B.W.

Diastopora, *Johnston.*

Zoarium adnate, discoid or flabelliform, or wholly or partly raised and bilaminate. Zoœcia tubular, with an elliptical or subcircular orifice, crowded and immersed towards the centre, more distinct and partially free towards the margins.
D. patina, *Lamarck.* B.M.C., Part III., p. 28 ; B.M.P., p. 458.
D. Sarniensis, *Norman.* B.M.P., p. 463.
D. bicolor, *M'G.* T.R.S.V., Dec., 1884.
Port Phillip Heads, J.B.W.
D. cristata, *M'G.* T.R.S.V., May, 1886.
Port Phillip Heads, J.B.W.
D. capitata, *M'G.* T.R.S.V., May, 1886.
Port Phillip Heads, J.B.W.

Liripora, *M'G.*

Zoarium crustaceous, growing on a basal lamina. Zoœcia not projecting, arranged in single or multiple series, forming raised ridges radiating more or less regularly from a central part, opening along the summits of the ridges or towards their extremities, intervening grooves occupied by a punctate calcareous membrane.

L. lineata, *M'G. sp.* T.R.S.V., 1884.

L. fasciculata, *M'G. sp.* T.R.S.V., 1884.
Port Phillip Heads, J.B.W.

Entalophora, *Lamouroux.*

(= Pustulopora, Bl., &c.)

Zoarium erect, branched; branches cylindrical or clavate, with the tubular zoœcia opening all round.

E. Australis, *Busk.* B.M.C., Part III., p. 21.

E. delicatula, *Busk.* B.M.C., Part III., p. 20.
Port Phillip Heads, J.B.W.

E. regularis, *M'G. sp.* T.R.S.V., Dec., 1882.

Family. DISCOPORELLIDÆ.

Zoarium irregularly shaped, discoid, cupped and partially free, or stalked, usually with a thin calcareous border. Zoœcia distinct, disposed irregularly or in radiating lines, with the intermediate surface cancellate or porous; or prismatic, of different sizes, and closely packed.

Lichenopora, *Defranc.*

Zoarium adnate or partially free, frequently discoid or cupped, usually growing on a basal lamina, with a thin external margin. Zoœcia partially free, disposed irregularly or in radiating series, with the intermediate surface cancellated; peristome usually lacerated or pointed to one side.

L. reticulata, *M'G.* T.R.S.V., Dec., 1883.

L. fimbriata, *Busk.* B.M.C., Part III., p. 32.
(? = L. hispida, *Fleming sp.*)

L. echinata, *M'G.* T.R.S.V., Dec., 1883.

L. pristis, *M'G.* T.R.S.V., Dec., 1883.

L. magnifica, *M'G.* T.R.S.V., July, 1886.
Port Phillip Heads, J.B.W.

L. bullata, *M'G.* T.R.S.V., July, 1886.
Port Phillip Heads, J.B.W.

L. radiata, *Audouin sp.* B.M.C., Part III., p. 32; B.M.P., p. 476.

L. Holdsworthi, *Busk.* B.M.C., Part III., p. 33.
Port Phillip Heads.

L. Wilsoni, *M'G.* T.R.S.V., Nov., 1886.
Port Phillip Heads, J.B.W.

Densipora, *M'G.*

Zoarium encrusting, discoid when young, when older thrown into ridges, the summits of which are fringed by smooth tubercles.

Zoœcia tubular or prismatic, closely packed, of varying size, with the mouth not projecting. No proper cancelli.

D. corrugata, *M'G.* T.R.S.V., April, 1880.

Favosipora, *M'G.*

Zoarium encrusting, flat or elevated into irregular ridges, the whole surface of which is occupied by zoœcia. Zoœcia prismatic, closely packed, of various sizes, usually not projecting, but occasionally with the mouth produced towards the edges of the zoarium or the summits of the ridges.

F. rugosa, *M'G.* T.R.S.V., 1884.

Flosculipora, *M'G.*

Zoarium small, pedunculate, the peduncle consisting of smooth tubes or ridges, with intervening cancelli towards the upper part. Zoœcia opening on the expanded summit, the peristome produced, dimidiate or lacerated, with numerous intermediate cancelli.

F. pygmæa, *M'G.* T.R.S.V., July, 1886.
Port Phillip Heads, J.B.W.

Family. FRONDIPORIDÆ.

Zoarium massive, stipitate, simple or ramose. Zoœcia tubular, connate, continuous from the base, aggregated into fasciculi, opening only at the extremities or in regular series at the sides of the branches. No cancelli.

Fasciculipora, *D'Orb.*

Zoarium erect, simple or branched or lobate. Zoœcia opening only at the extremities of the branches or (in *F. bellis*) in one or more regular series below the extremity.

F. gracilis, *M'G.* T.R.S.V., Dec., 1882.
F. bellis, *M'G.* T.R.S.V., Dec., 1883.
F. fruticosa, *M'G.* T.R.S.V., Dec., 1883.
F. ramosa, *D'Orb.* B.M.C., Part III., p. 37.
Portland, C.M.

Sub-Order III. CTENOSTOMATA, *Busk.*

Family. FLUSTRELLIDÆ.

Zoarium adherent or erect, gelatinous. Zoœcia with a bilabiate orifice.

Frustrella, *Gray.*

The only genus.

F. cylindrica, *Hincks.*
(= F. hispida, var. cylindrica, *Hincks.* A.M.N.H., May, 1884).

Family. VESICULARIIDÆ.

"Zoœcia contracted below, not closely united to the stem at the base, deciduous, destitute of a membraneous area."

Amathia, *Lamouroux.*

Zoarium consisting of a creeping tubular stem and erect filiform shoots, dichotomously branched. Zoœcia subtubular, in two parallel rows, continuous or in distinct groups, which are placed on one or both sides of the stem, or wind spirally round it.

A. Australis, *Tenison Woods.* P.R.S., N.S.W., 1877.
A. spiralis, *Lamx.* T.R.S.V., 1880.
A. tortuosa, *Tenison Woods.* T.R.S.V., 1880.
A. bicornis, *Tenison Woods.* T.R.S.V., 1880.
A. inarmata, *M'G.* T.R.S.V., Nov., 1886.

Group B. Entoprocta, *Nitsche.*

Order II. PEDICELLINEA, *Gervais.*

Family. PEDICELLINIDÆ.

Polypides borne on a retractile peduncle, united in colonies by a creeping stolon.

Pedicellina, *Sars.*

Polypides pedunculate, distributed along a creeping, ramified stolon, the body separated by a diaphragm from the stem and deciduous; tentacular crown terminal.

P. ———— *sp.*
Queenscliff.

Pedicellinopsis, *Hincks.*

"Polypides cup-shaped, supported on chitinous tubes with a much enlarged base (consisting of an opaque white core, probably muscular, enveloped in a chitinous covering) by which they are attached to an erect tubular stem. Zoarium adherent by means of tubular root fibres."

P. fruticosa, *Hincks.* A.M.N.H., May, 1884.
Port Phillip Heads, J.B.W.

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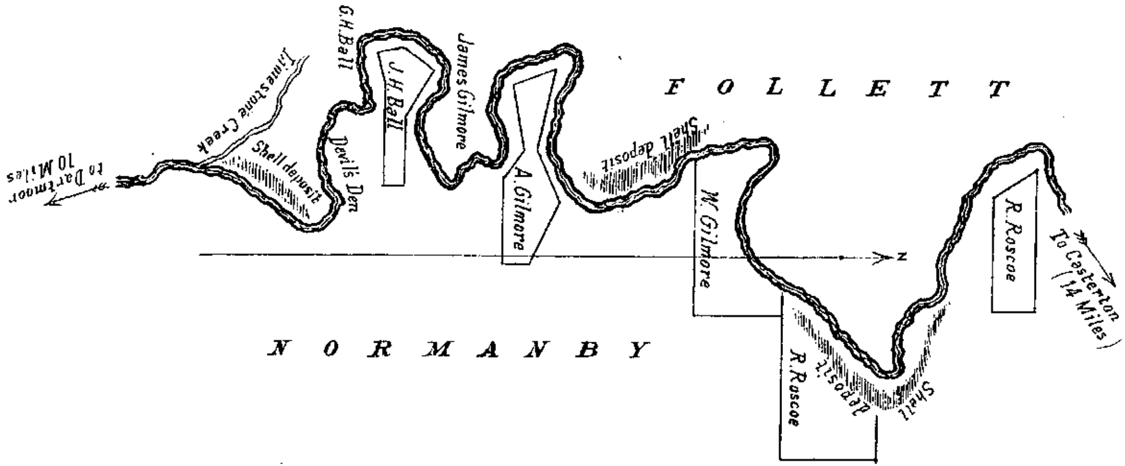
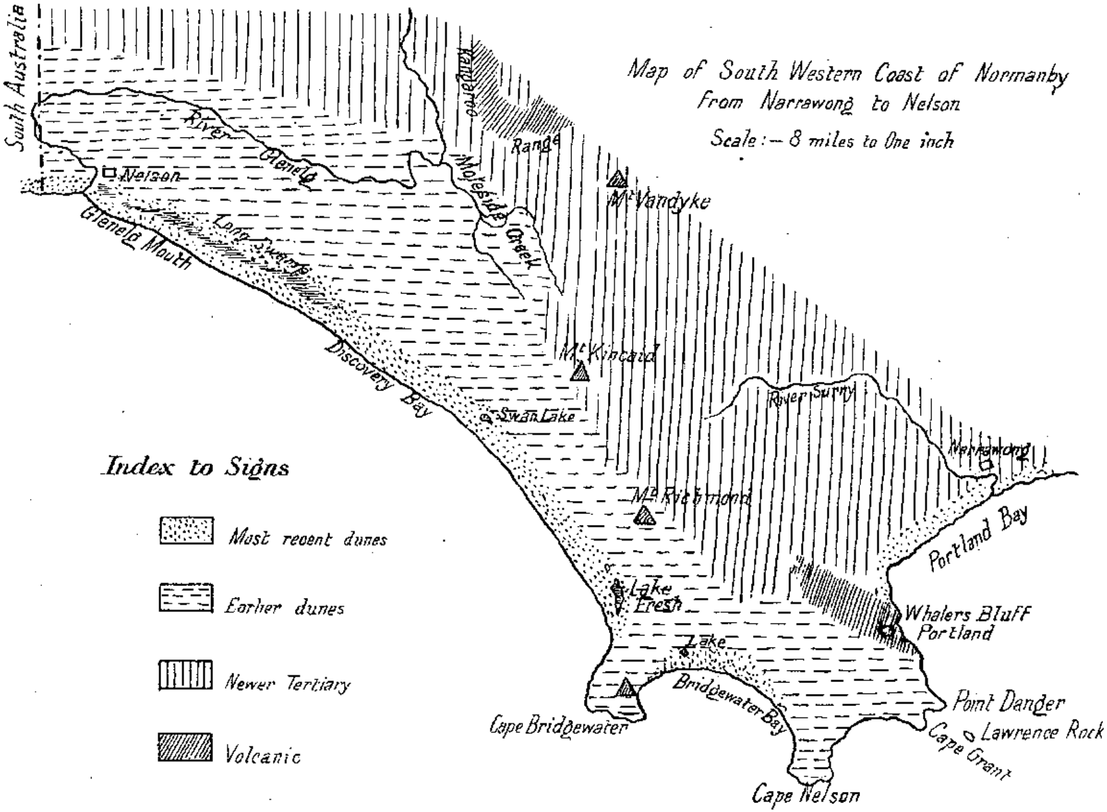


Map of the Glenelg River from Roscoe's to Limestone Creek

Scale:— 80 Chains to an Inch


Map of South Western Coast of Normanby
From Narrawong to Nelson
Scale:— 8 miles to One inch
South Australia
River Glenelg
Nelson
Glenelg Mouth
Long Swamp
Kangaroo Range
Moleside Creek
Mt Vandyke
Mt Kincaid
Discovery Bay
Swan Lake
River Surry
Narrawong
Mt Richmond
Portland Bay
Lake Fresh
Whalers Bluff
Portland
Lake
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Cape Bridgewater
Point Danger
Lawrence Rock
Cape Grant
Cape Nelson
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Art. XVII.—*Notes on Post Tertiary Strata in South-Western Victoria.*

By John Dennant, F.G.S.

[Read 11th November, 1886.]

I.—*Dune Limestone*, Recent.

Amongst the prevailing tertiary strata in the counties of Follett and Normanby there are certain deposits of still later age, which, though limited in extent, are, from their mode of occurrence, of great geological interest. They may be arranged chronologically into two distinct sets of beds, the most recent of which will be first considered.

If the traveller leaves Portland to go to the pleasant little watering-place at Cape Bridgewater, he is struck by the sight of an outcrop of rock dipping at various angles amongst the consolidated sand dunes through which the road winds. The strata are very abundant along the coast from Portland to the border of the colony, and for many miles farther west in South Australia. They are met with also for a short distance inland, but chiefly in quarries, being usually hidden from view on the surface by a thin covering of drift sand. The only use of the rock is as a rough kind of building stone, where other materials are not available. Churches, schools, &c., constructed of it are generally pointed off with a finer kind of stone, and these have, for bush edifices, quite a passable appearance. Being of a very porous nature, the blocks of stone used need to be thick to avoid damp; but even then this defect renders it undesirable for dwelling-houses.

The strata are highly laminated, the weathered edges breaking off into leaves as thin as flags of roofing slate, with the laminations, of course, always parallel to the bedding planes. These, however, are seldom horizontal, the most characteristic feature of the beds being their constantly changing dip, not only in direction, but also in amount. The highest observed inclination was 30 degs., but between this and 0 deg. almost any angle may be found.

Locally the rock is called sandstone, from its coarse appearance, but it is essentially a carbonate of lime, the silica obtained from a sample analysed being as low as 4 per cent. In composition it perfectly resembles the sand of the coast dunes, a coincidence which it is important to note in discussing the origin of the formation.

Between Portland and M'Donnell Bay there is a fringe of these dunes, or sand hummocks, as they are often called, extending from the sea margin to a distance of from one to three miles inland. Their altitude is considerable, many being 100 feet, and some even exceeding 200 feet, in height. They consist simply of sand, which, first washed on shore by the waves, has then been heaped up higher and higher by strong southerly winds. Within their land and sea boundaries flats and hollows are frequently left, and here pools and small lakes of fresh water are sometimes formed; or, again, the whole space is occupied by a series of smaller dunes, disposed in the most irregular manner. Usually there is no vegetation, and nothing meets the eye but glistening masses of white sand, making a landscape of the most weird and desolate character.

The bare dunes of the coast are succeeded for a few miles inland by others, which, in the course of time, have become covered with vegetation; but their rounded outlines are still preserved, giving to the region where they occur an undulating, billowy appearance, the contour of the land being exactly what would result from the gradual upheaval of successive rows of dunes, similar to those now forming on the seashore. As we go farther inland the country becomes less and less undulating, until, at a distance of 10 or 12 miles, the level plains of the interior are reached. Although sand is abundant here, there are no dunes, and they were either never formed, or have been since entirely removed. It is most likely that the coast action, which favoured the accumulation of sand into dunes, did not begin to operate till after the elevation of the plain country. Even in some localities where there are extensive sand hummocks on the sea margin no inland dunes exist; but we may easily account for their absence in such places by supposing the shore outline to have been different in former times. There are indeed indications of considerable alteration in this, particularly in the volcanic region around Portland, where the coast is both broken and precipitous, many bays and headlands having been formed by inroads of the ocean. It is further evident that these changes have taken place since the deposition of the earlier dunes, as their consolidated remains are plainly visible amongst the cliffs.

Such is the case at Nelson Bay, where a section of the strata is exposed more than 100 feet in thickness, the whole internal structure of the dunes being laid bare. The dip is quaquaversal, and the face of the cliffs presents precisely the appearance that might be expected from a perpendicular cut through a series of hardened sand dunes. At the top the actual rounded outlines of the original dunes are distinctly shown toward the landward side, while the seaward portions have been carried away by the action of the waves and spray. At Cape Grant, a little farther east, and on the western side of Cape Bridgewater, the coast features are exactly similar—viz., ridges rounded on one side, but abruptly terminated on the other by steep cliffs, the inclination of the beds also continually changing.

On the peninsula joining Cape Bridgewater to the mainland a still more instructive section of the strata may be observed. Just on the rising ground facing the Bay a landslip has occurred, by which a consolidated sand dune has been cleft from top to bottom, the two portions being now separated by a wide chasm. The rocks on both sides are very hard, and from weathering, their laminated structure is well illustrated, the edges standing out prominently in thin flags. Their ever-changing dip is, however, the most interesting feature, as, besides being typical of the formation generally, it permits us in this case to trace the former junction of the two masses, for although the dip is so various on either face, ranging from 30 degs. to 0 deg., yet at exactly opposite parts of each it is the same. The prevailing slope where the break has taken place is towards the severed portion—that is, seaward, and to the undermining action of the waves must, no doubt, be attributed the subsidence of such an immense mass of material. It is probable that, in the course of time, the whole of it will yet be removed, leaving then only the upper face as a cliff immediately overhanging the sea. With such an example before us, it is not difficult to account for the sharply-cut cliffs at Nelson Bay and other places on the coast. The fractured sand dune at Cape Bridgewater has been appropriately named "The Cloven Rock," and it is pointed out to visitors as one of the natural wonders of this favourite summer resort.

The dunes amongst which these bold cliffs occur have existed for some time, as their tops are now clothed with verdure; but if those more recent and still barren mounds on the sea-beach are examined, it becomes apparent that their gradual consolidation is producing a similar rock. Thus, at Swan Lake, in the very heart of the drifting sand hummocks, the rock crops out where the overlying sand of a *partially* consolidated dune has been blown away by the wind, the exposed hardened portions showing the quaquaversal dip that is so striking in the Nelson Bay cliffs. Indeed, on the very margin of this small lake, minor cliffs have been formed, which are miniature copies of those against which the foaming waves of the Southern Ocean dash themselves. Occasional outcrops of the rock may, in fact, be found in almost any part of the hummock region from Portland Bay to the boundary of the colony. At the Glenelg mouth it is seen in different stages of formation, from solid rock down to that which is so loose and crumbling as to give way at the slightest touch.

With the aid of a lens the component parts of the rock can be fairly well distinguished. Little white specks, which run pretty evenly through it, are simply small pieces of shells, usually thin and sharp; but the main mass consists of rounded fragments of corals, bryozoa, &c. It is true that whole shells are sometimes found among the recent hummocks, and their absence from the rock might at first sight seem strange; but it must be remembered that the sand is in continual motion, being drifted hither and thither by the force of the wind, and long before consolidation could take place they would be broken into unrecognisable fragments. At Bridgewater and other places where the sand is still unconsolidated, recent shells are found, not only in hollows, but also for a considerable distance up the dunes. It is not difficult, however, to understand how they came there, since shells are at the present day being deposited on the shifting sand dunes of the beach in precisely the same manner, washed up, no doubt, by the surf during storms. It is evident that these mounds of loose sand can never have been submerged after being once formed, or they would speedily have been levelled by the waves.

The same remark may, of course, be made with regard to the inland dunes, while they were yet in the unconsolidated state; and it is probable that a gradual elevation of the coast-line has continued during the formation of the entire series of dunes.

There are two minor deposits on the coast which may be mentioned here. At Narrawong, and also near the mouth of the Glenelg, on the landward side of the coast hummocks, and at a lower elevation than these, a thin stratum of limestone occurs, full of shells, exactly like those on the adjacent beach. It is a kind of travertine, which while forming has enclosed the shells left on the low-lying ground. The localities where it has been observed are not now more than 30 feet above sea level. Though contemporaneous with the sand-dunes, it is an independent deposit.

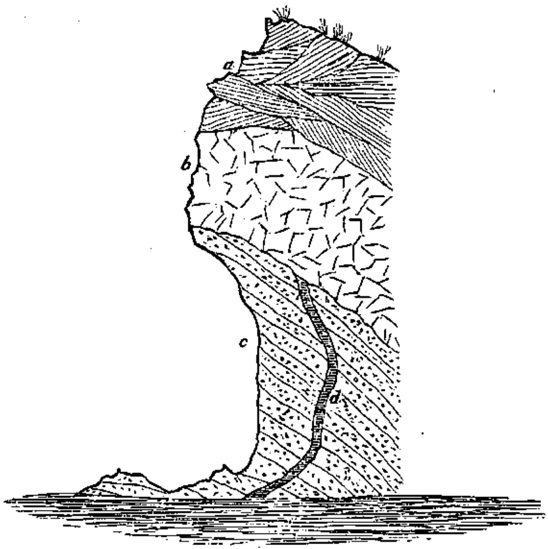
In many places near the coast, where from local circumstances neither travertine nor sand-dunes have been formed, similar shells are found in the soil or in patches on the surface of the ground. They are chiefly interesting from the additional proof they afford of the upheaval of the land in quite recent times.

It is necessary to notice also that in one or two localities narrow ridges of the dune limestone jut out seaward for a short distance, but their presence in such a position may be accounted for, I think, by supposing minor alterations of the coast line to have taken place subsequent to the consolidation of the strata. Near the Glenelg mouth, two of these outcrops occur within a few miles of each other, only one of which I have had an opportunity of examining closely—viz., that nearest the river. In it the rocks commence on the beach, and extend about a hundred yards from the land, when they terminate abruptly. The ridge is not more than 20 or 30 feet high, and a dozen yards in width in any part; nor is it continuous, bare spaces being left here and there, where no signs of rock appear. The second outcrop, as seen from a distance, looks very similar, and both are probably the remains of low headlands, which the waves have almost succeeded in demolishing.

That the deposit is not deep-seated is plainly enough demonstrated, when the volcanic country surrounding Cape Bridgewater is examined, as its junction there with the underlying igneous rocks is conspicuously displayed on the face of every cliff. These rocks belong to a lava flow which issued from an extinct vent in the vicinity prior to the formation of the sand dunes. The two sets of beds meet a good way up the cliffs, but not at a uniform level, the surface of the basalt being far from horizontal, while the thickness of the limestone in any place depends, of course, upon the varying height of the original mounds of sand, of which it is a consolidated remnant. The Lawrence Rock, off Cape Grant, is an outlier of the same strata, now separated from the mainland by a channel deep enough for navigation by small vessels, and just as on the cliffs of the adjoining cape, the lower portions consist of basalt, and the upper of limestone.

The mode in which the volcanic rocks of this neighbourhood occur is of special interest, as it enables us to note the relative age, not only of the dune limestone, but also of the underlying sedimentary strata. At the Whaler's Bluff, Portland, three separate formations are exposed in section—viz., the coralline (miocene) at the bottom, next the oyster beds, and finally the basalt at the top. Here the dune limestone is absent, but as the coast is traced round to the west, it soon appears, crowning the lava on the cliffs at Cape Grant. In no case are the igneous rocks covered by any other deposit, and it is, therefore, the most recent of all.

The extinct crater from which the fiery stream proceeded must have been situated somewhere near the sea margin, either on the land, or at a very short distance from it. Skirting Discovery Bay is a series of low cones, extending from Mount Vandyke on the north to Mount Richmond on the south. Now, Cape Bridgewater is itself a volcanic hill, and is, moreover, the most southerly extension of the same line of disturbance, its distance from the last-mentioned elevation being only six or seven miles. An examination of the cliffs at this promontory will prove, I believe, that here we have the source of most of the basalt underlying the dune limestone. The highest point of the cape is 460 feet above sea level, and is found at about a mile from its extremity, close to the cliffs overlooking Bridgewater Bay. By walking along at the base of these, on what is called the "flat rock," and looking upwards, we see the internal structure of what is evidently an old volcanic cone completely disclosed. The lowest portions, including the rock on which we stand, consist of stratified volcanic ash, of a greyish brown colour, with angular pieces of basalt, varying in size from minute grains up to fragments as large as a man's head, thickly scattered through it, the whole being cemented together so firmly as to form a tolerably hard stone. Above it is covered by a layer of ropy, scoriaceous lava, which has welled out of the old crater after the first discharge of lapilli and dust. In places, the ash deposit is almost horizontal, but towards one particular spot it shows a gradually increasing inclination up to a maximum of about 30 degs. Just here a vertical dyke of lava, not more than a foot thick, intrudes completely through it, and joins the once molten mass at its top. Being very dense and compact, it has been able to resist the degrading action of the waves longer than the more friable material on each side, from which it now stands out like a projecting wall.



SKETCH SECTION OF CLIFF AT CAPE BRIDGEWATER.
a, Dune limestone; *b*, basalt; *c*, volcanic ash; *d*, lava dyke.

On the western side of the cape no ash is visible, the basalt reaching down to the water's edge. The same is the case at its southern extremity, and the centre of volcanic activity must thus have been somewhere on its eastern side.

It should be mentioned that at the top of all the cliffs there is the usual deposit of dune limestone, but only up to a height of about 250 feet, that portion of the promontory which still rises by a gradual slope some 200 feet higher, showing no trace of it, the basaltic rocks cropping out instead on the surface. The volcanic mound, therefore, of which Cape Bridgewater is a remnant, was probably formed near the shore, its summit first appearing above the surrounding waves, while the sheets of lava which issued from it were spread out on the sea bottom, their present elevated position being due, of course, to a subsequent steady upheaval of the southern coast; as the rocks slowly emerged from the ocean, deposits of calcareous sand accumulated upon them, which, having consolidated, now remain as stratified beds overlying the basalt.

II.—*Bankivia Beds,* Pleistocene.

I have next to call attention to a remarkable fossil deposit on the banks of the Glenelg river, almost midway between Casterton and Dartmoor. Some shells from this neighbourhood were given to me about three years ago, and Professor Tate, to whom they were submitted, pronounced them to be recent and to be represented for the most part by species now inhabiting the adjoining seas. Subsequent collections included a very few of rather older appearance than the rest, reducing the percentage of living species slightly. It was a great surprise to find such fossils so far from the coast, and I took the first opportunity of visiting the locality and noting the position of the beds.

The shells occur in abundance on the very margin of the Glenelg, just at the junction of the Limestone Creek with it, and along the banks of the river as far up as the Old Pieracle station, where a selector now lives named Roscoe, from whom I have received much help in my search for fossils. The deposit appears to cease here, as no shells were found farther north, the bed of the river, as well as the banks for 40 or 50 feet up, being composed of drift full of quartz pebbles, mica, and nodules of ironstone (limonite). It extends, however, for some distance below Limestone Creek: how far it would be difficult to determine exactly, as the beds thin out gradually. The most notable spots for shells are situated between the places mentioned.

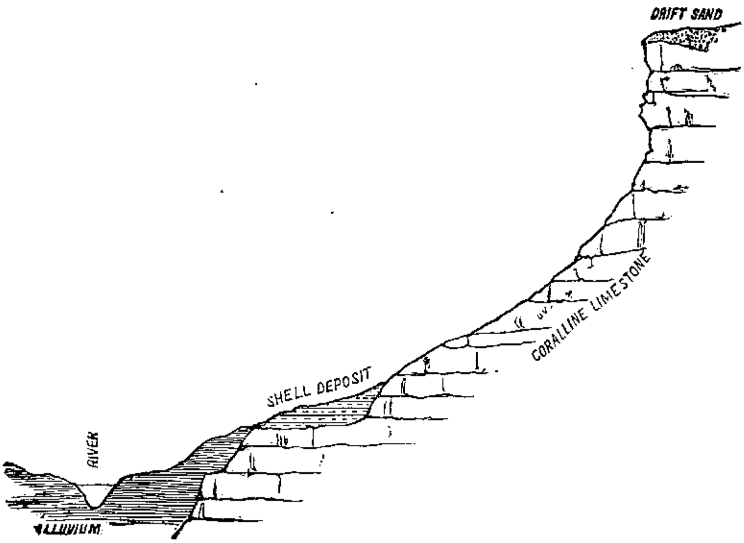
The nearest point of the coast is about 25 miles in a direct line from Limestone Creek, but the river meanders along for fully 120 miles before it discharges itself into the sea at Nelson.

About half a mile above the Limestone Creek junction, near a romantic spot known as the Devil's Den, the bank of the river is a mass of stone containing numerous oyster and other shells confusedly mixed together. Sometimes the carbonate of lime forms a cement by the partial dissolving of the shells themselves. It has made quite a hard stone; but the shells are principally on the surface, standing out clear, and not looking as if an integral part of the stone. A similar rock was mentioned in the first part of this paper as a recent formation at Narrawong, Nelson, &c., the only difference being that in it the enclosed shells are the most common ones of the present sea beach; while in the Glenelg deposit a few of them are not now found on the coast. The shells at the Devil's Den occasionally encrust blocks of an older-looking rock, which are scattered here and there on the river banks: their origin will be explained presently. At a height of about 30 feet from the summer level of the water, there is a mass of conglomerated material, composed of clay, limestone, sand, &c., full of marine shells. The bank on which it occurs is on the edge of an extensive flat, over which the river sometimes flows in winter.

On the left bank of the river, opposite Roscoe's, the margin of the stream is in places covered by immense numbers of shells, reminding one forcibly of sheltered coves on the sea shore. Bivalves are very plentiful, particularly *Pectunculus obliquus, Leda crassa, Chione roborata, &c.* The univalves are mostly small, but large ones, such as *Fasciolaria fusiformis, Voluta undulata,* &c., are sometimes found, though they are generally more or less injured by being washed about, either by the river waters, or by the waves of the sea, which deposited them on a former beach.

A little higher up the stream, on a hill or point of land cut through by a small creek, a very friable rock crops out, consisting almost entirely of shells, loosely adhering together. Most of them belong to a species still extremely common on the coast—viz., *Bankivia purpurascens.* So abundant are they in this crumbling rock, that at first sight it seems to be composed of nothing else. They are present in thousands, nearly all quite perfect, and retaining their colour as completely as if just washed up by the tide. It is from the prevalence of these shells that I have called the deposits "Bankivia beds." They are, however, by no means the only shells in the place, as by examining the rock and the *debris* around, a great variety of species can be found. This is the most interesting outcrop of the fossil-bearing strata anywhere on the river. Its position and the fresh appearance of the shells give clear evidence of its being an original deposit. The spot where it occurs lies about 60 feet above the river bed, and is the greatest elevation at which I could find shells. The river never perhaps rises so far above its present channel, and the majority of the shells in the low-lying ground cannot come from here, but are derived from less elevated portions of the same strata. Near the same place, indeed, there are shell-beds at only half this height, and therefore quite within the reach of flood waters. The heights to which floods have risen are known to residents by marks on trees, &c., and some of these, which were shown to me, must be fully 40 feet above the bed of the stream.

The hill, and the other shell-banks in its vicinity, are on the margin of an irregular terrace, which continues all along the river in this part of its course, at a height of from 30 to 60 feet above its bed. In the terrace there are occasional mounds or banks, but it usually forms extensive flats. Through these the river winds in such a tortuous manner that, to go in a straight line from bank to bank of the gorge, which is sometimes nearly two miles in width, the stream might have to be crossed two or three times.



SKETCH SECTION. LEFT BANK OF GLENELG GORGE AT ROSCOE'S.

It is noticeable that the river frequently hugs one bank for some distance, and then crosses over to the other, so that the flats succeed one another on opposite sides of it. The same thing was observed by Professor Tate as a feature of the Murray*. In some other respects the two river gorges resemble each other, allowing for difference of size.

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* *Transactions Royal Society of South Australia*, 1884.

The shell beds, both at Roscoe's and the Devil's Den, are always near the main banks of the river, and when found along the one, they are generally absent from the other. I have seen no shells towards the middle of the flats, but these are, for the most part, covered by alluvium and sandy drifts, which conceal the underlying strata. Every flood, however, leaves behind a fresh deposit of shells in the bed, and on the margin of the stream, washed out from the fossiliferous portions of the terrace by storm waters. I am told that when a landslip of the black alluvium takes place, the shells are exposed in great numbers. Beneath the superficial accumulations there are probably numerous beds of shells, not perhaps regularly stratified, but forming banks in various parts.

The terrace just described is not, however, the only one in this part of the river's course, as between it and the water's edge there is usually another and much narrower one. This lies about 20 feet below the upper terrace, and extends for 20 or 30 yards only on either side of the river. I could find but few shells in it, and these few were always near the surface, as if they had been simply washed there from the higher ground.

The spots referred to as so thickly strewn with shells lie at a lower level still, and are merely the sloping banks of the river channel itself. The shells deposited upon them can, of course, only be gathered when the water is low.

The main banks of the river are at a height of from 130 to 160 feet above its bed, and thus from 70 to 100 feet higher than the upper terrace, the ascent from which to the banks above is often steep, and sometimes even perpendicular. The terraces follow closely the windings of the river, but the topmost banks bound its general course only. The Glenelg flows for about two-thirds of its length through a very wide, as well as deep, valley, though the river itself is but a moderate one. The depth of the gorge is tolerably uniform, but its width varies considerably, being greatest in the neighbourhood of the fossil beds, where it is, as I have said, nearly two miles across. It is about half this width a few miles to the north, and narrows also, though more gradually, to the south of Limestone Creek.

With the summit of the Glenelg banks commence the wide plains forming the heath and scrub lands of Follett and South Normanby. Occasionally, there is a gentle rise of 20 or 30 feet before the tableland is reached, though, as a rule, the edge of the gorge is quite as high as the country farther inland. The same general level is maintained right down to the coast, interrupted by no other depressions than those formed by the river itself and its few tributaries.

The total number of species gathered up to the present time from these beds is 141. Of this number 7 are too worn for perfect identification, and 13 belong to species which have not been met with before, either fossil or living. The known species therefore amount to 121, of which 98 are recent only, while 15 others, besides being recent, are fossil also in other formations. The remaining 8 species occur as fossil only, chiefly in the older tertiaries of Victoria, South Australia, &c.

The following table contains a list of the various species, and also their distribution*:—

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	Abbreviations— O.T. = Older Tertiary. a = upper beds, Older Tertiary. b = lower beds, Older Tertiary.
Echinodermata—								
Goniocidaris ?	..	..	..	..	..	..	..	Spine only.
Brachiopoda—								
Waldheimia sp.	..	..	..	..	..	..	..	Too worn for identification.
Lamellibranchiata—								
Ostrea Angasi, *Sow.*	..	*	*	*	..	*	*	Pareora and Wanganui systems, N.Z
Gryphaea tarda, *Hutton* ..	..	..	..	..	..	..	..	O.T. S. Austr. (b), N.Z. (b).
Placunanomia Ione, *Gray* ..	..	*	..	*	..	..	*	O.T. S. Austr. (a), Muddy Creek (b).
Pecten asperrimus, *Lam.* ..	..	*	*	*	*	..	*	
——— bifrons, *Gray*	..	*	*					
Limea austrina, *Tate*	..	*						
Mytilus Menkeanus, *Phil.* ..	..	*	..	..	*			
——— hirsutus, *Lam.*	..	*	*	*	..	..	..	Living also in Japan
——— Magellanicus, *Lam.* ..	..	..	..	..	..	..	*	Living also in South America. Fossil in Pareora and Wanganui systems, N.Z

* I wish here to express my great obligation to Prof. Tate, F.G.S., F.L.S. for his kindness in determining for me the species of these shells. I am indebted to him also for much of the information given in the table.

Species found in Limestone Creek beds.	Living. Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	Localities where Fossil, and Remarks.
Lamellibranchiata—								
Nucula obliqua, *Lam.*			*			*		Living also in New Guinea.
Leda crassa, *Hinds*	*	*	*	*				Living also in Q'sld.
Barbatia radula, *H. Adams*	*	*	*					
Limopsis Belcheri, *Ad. & Reeve*	*	*						Living also at C. of Good Hope. Fossil in Pleistocene, S. Austr., O.T. do. (a), Muddy Crk. (a & b).
Pectunculus obliquus, *Reeve*		*	*		*			
—— planiusculus, *Tate m.s.*								New species.
—— flabellatus, *T. Woods*	*	*	*					
Cucullaea Corioensis, *M'Coy*								O.T., S. Austr. (b), Tasmania (a), Muddy Creek (b)
Trigonia acuticostata, *M'Coy*	*							O.T., S. Austr. (a), Muddy Creek (a).
Mytilicardia crassicostata, *Lam.*	*	*			*			
Cardita bimaculata, *Deshayes*			*					
—— Gunnii, *Deshayes*			*					
Lucina quadrisulcata, *D'Orb.*		*	*	*			*	O.T., S. Austr. (a), Pareora, Wanganui, and Oamaru systems, N.Z.
Chione gallinula, *Lam.*		*	*	*	*			
—— roborata, *Hanley*		*	*					
—— aphrodina, *Lam.*	*	*	*		*			
—— scalarina, *Lam.*		*	*		*			
—— undulosa *Lam.*		*		*	*	*		
—— sp.								? New species; much worn.
—— sp.								Too worn for identification.
Cytherea rutila, *Hanley*	*	*	*	*				
Venerupis exotica, *Lam.*		*				*		
Dosinia anus, *Phil.*							*	
Mesodesma erycinaea, *Lam.*			*					Living also at Singapore.
Anapa triquetra, *Hanley*		*	*					
Sunetta Alicae, *Adams & Angas*		*						
Zenatiopsis angustata, *Tate*								O.T., S. Aust., Table Cape, Muddy Crk. (a).
Mactra sp.								? New species.
—— sp.								? New species.
Hemimactra sp.								? New species.

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	
Lamellibranchiata—								
Donax cardioides, *Lam.*	..	*	..	..	..	*	..	Lives also in New Guinea.
Corbula tunicata, *Hinds*	..	..	..	*	..	*	..	Lives also in Philipines.
Myodora ovata, *Reeve*	..	*	*	*				
Barnea australasiae, *Gray*	..	*	*	..	..	..	*	
Gasteropoda—								
Murex octogonus, *Quoy & G.*	..	*	*	*	..	..	*	Wanganui system, N.Z.
Urosalpinx Paivae, *Crosse & F.*	..	*	..	*	..	..	*	
Epidromus Bednalli, *Brazier*	..	*						
Triton gibbus, *Tate*	..	..	..	..	..	..	..	O.T., Muddy Crk. (b)
——— Quoyii, *Reeve*	*	*	*					
——— Bassii, *T. Woods*	*	..	*					
Purpura textiliosa, *Lam.*	*	*	*	..	..	..	*	Pareora system, N.Z.
Cantharus Clarkei, *T. Woods*	*	..	*					
Trophon Petterdi, *Crosse*	..	..	*					
——— Paivae, *Crosse*	*	*	*	..	..	..	*	
——— sp.	..	..	..	..	..	..	..	? New species.
Fusus ustulatus, *Reeve*	..	*						
——— australis, *Quoy*	..	*	..	..	..	..	..	Pareora and Wanganui systems, N.Z
——— sp.	..	..	..	..	..	..	..	? New species.
Cominella costata, *Quoy & G.*	*	*	*	..	..	..	*	Wanganui and Awamoa systems, N.Z.
——— sp.	..	..	..	..	..	..	..	? New species.
Eburna (Zemira) australis, *Sow.*	..	..	*	*				
Nassa monile, *Kiener*	*	*	*	..	..	..	..	Living also in Polynesia.
——— fasciata ? *Chem.*	*	..	*					
——— lirella, *Beck*	..	*						
——— sp.	..	..	..	..	..	..	..	(aff. Jacksoniana, *Kiener.*)
Fasciolaria fusiformis, *Valenc*	*	*	*					
Columbella Lincolnensis, *Reeve*	*	*	*	*	*			
——— infumata, *Crosse*	..	*						
——— Angasi, *Brazier*	..	*	*	*				
——— Yorkensis, *Crosse & F.*	..	*						
Terebra ustulata, *Deshayes*	..	..	*					
——— spectabilis, *Hinds*	..	..	*	*	..	..	..	Living also at New Guinea & Sumatra
——— strigillata, *Linn.*	..	..	..	..	..	*	..	Living also in Polynesia.
Euryta pulchella, *Adams & Angas*	..	*						
Voluta undulata, *Lam.*	..	*	*					

Species found in Limestone Creek beds.	Living. Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	Localities where Fossil, and Remarks.
Gasteropoda—								
Voluta fulgetra, *Sow.*	*	*	*					
——— mamilla, *Gray*	..	..	*					
Mitra scalariformis, *T. Woods*	..	..	*					
—— maculosa, *Reeve*	..	..	..	..	..	*	..	Living also in Polynesia and Red Sea.
—— Rosettae, *Angas*	..	*						
—— glabra, *Swainson*	*	*	*	*	*			
Imbricaria conovula? *Q & G.*	..	..	..	..	..	..	..	Living in Polynesia.
Marginella turbinata, *Sow.*	*	*	*	*				
———— Allporti, *T. Woods*	..	..	*					
———— Johnstoni, *Petterd*	..	..	*					
———— Tasmanica, *T. Woods*	..	..	*					
———— volutiformis, *Reeve*	*	*	*					
———— Stanislas? *T. Woods*	..	..	*					
———— ovulum, ? *Sow.*	..	..	..	*	..	..	..	O.T., Muddy Crk. (a)
———— formicula, *Lam.*	*	..	..	*				
Ancillaria australis, *Sow.*	*	..	..	..	..	..	*	Pliocene, N.Z. O.T., Muddy Crk. (a & b)
———— marginata, *Lam.*	*	*	*	*				
Clathurella bicolor, *Angas*	..	*	*	*				
Pleurotoma violacea, *Hinds*	..	..	..	..	..	*	..	Also living in New Guinea and Japan.
———— sp	..	..	..	..	..	..	..	Not yet named. O.T. Muddy Creek (b).
———— sp	..	..	..	..	..	..	..	Undetermined.
Clavatula monile, *Valenc*	..	..	..	..	..	*	..	Living in Pacific Ocean.
Mangelia Jacksonensis, *Angas*	..	..	..	*				
Cassis fimbriata, *Quoy & G.*	*	*						
Semicassis semigranosa, *Lam.*	*	*	*	..	*			
Trivia australis, *Lam.*	*	*	*	*	*	..	*	
Cancellaria granosa, *Sow.*	*	*	*	*				
———— sp.	..	..	..	..	..	..	..	Not yet named. O.T. Muddy Creek.
Potamides dubium, *Sow.*	..	*						
Turitella sp.	..	..	..	..	..	..	..	New species.
———— sp.	..	..	..	..	..	..	..	? New species.
Natica aurantia, *Lam.*	..	..	..	..	..	*	..	Living in Indo-Pacific.
——— conica, *Lam.*	*	*	*	*	*			
——— semifilosa, *Tate m.s.*	..	..	..	..	..	..	..	New species.
Crepidula monoxyla, *Lesson*	..	..	..	..	..	..	*	Pareora and Wanganui systems, N.Z
Trochita maculata, *Quoy*	..	..	..	..	..	..	*	Pareora and Wanganui systems, N.Z
Amalthea conica, *Schum.*	..	*	*					

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	
Gasteropoda—								
Philippia lutea, *Lam.*				*			*	
Astele granosa, *Tate m.s.*								New species.
Zizyphinus Meyeri, *Phil.*	*	*	*	*				
——— Legrandi, *T. Woods*			*					
Chlorostoma sp.		*						
Bankivia purpurascens, *Beck*	*	*	*	*			*	Living also at Cape of Good Hope.
Euchelus Tasmanicus, *T. Woods*		*	*					
Clanculus variegatus, *Adams*	*	*	*		*			Also living in Phillipines.
——— Aloysii, *T. Woods*		*	*					
Thalotia Allporti? *T. Woods*		*	*					
Diloma odontis, *Gray*	*	*	*					
Liotia australis, *Kiener*	*	*	*					
Risella melanostoma, *Gmelin*	*	*	*		*			
Phasianella ventricosa, *Q. & G.*	*	*	*	*	*			
Turbo circularis, *Reeve*		*	*					
——— squamiferus, *Koch*		*	*					
Fissurella concatenata, *Crosse*	*	*	*	*				
Emarginula candida, *A. Adams*		*		*			*	
Acmaea marmorata, *T. Woods*	*		*	*				
Cylichna arachis, *Quoy*	*		*	*	*			
Scaphopoda—								
Entalis Mantelli, *Zittel*								O.T., N.Z. (b); S. Austr. (b); Muddy Creek (a & b)
——— annulatum, *Tate*								O.T., S. Austr. (b); Muddy Crk. (a & b)
Pulmonata—								
Helix coriaria, *Pfr.*				*				
——— sp.		*						(aff. Strangei).
Succinea australis, *Quoy & G.*	*	*	*					
Ampullarina ? sp.								Undetermined.
Pisces—								
Lamna sp.								Tooth.
Oxyrrhina (or Lamna) sp.								Tooth.

Reference has been made to the abundance of oyster shells amongst the Bankivia deposits, while no oysters are now found on our coasts, and the occurrence of these, as well as of the extinct shells mentioned, renders it desirable to speak briefly of the more ancient strata, through which the Glenelg has carved out the southern part of its course—viz., the coralline limestone. The thickness of this is unknown, but that it is very great is certain, from the fact of there being no outcrop of a different rock for many miles in any direction. It underlies the bed of the river from its mouth almost as far as Casterton, where mesozoic and silurian rocks appear. Its fossils are numerous, and fairly well known; from their evidence the whole formation is considered to be of miocene age. At the Devil's Den is a massive cliff, 130 feet high, composed of this rock, and covered by a band of oyster shells, as is usual with the strata generally. Near it, similar though smaller cliffs exist towards the summit of the banks, while farther down the river, the limestone is continuous to the water's edge. At Ascot Heath, about ten miles south from Limestone Creek, the oyster beds at the top of the bank are as much as 8 or 10 feet thick, the coralline rock with its characteristic fossils lying immediately underneath. The oysters found on the Glenelg terraces are of the same species as those in the cliffs above; but it does not necessarily follow that they are derived from this source, their great abundance in the Bankivia beds being against such a theory, and we can only conclude that they were common to both formations. The small variety of fossils in the Ostrea limestone renders the determination of its age difficult, but it is undoubtedly much less ancient than the coralline strata, as amongst the few fossils which have been obtained from it, several are identical with living forms, while, as is well known, a large proportion of those in the coralline belong to extinct species.

Again, *Entalis annulatum*, *Cucullaea Corioensis*, &c. are frequent shells in the coralline formation, and the possibility of their derivation from it must be admitted. There are, however, certain considerations which induce me to take an opposite view, and to regard *them* also as part of the original deposit. Five of the eight extinct shells are very rare, being represented in my collection by solitary examples only, while specimens of most other species are tolerably numerous. With the exception of *Gryphaea tarda*, they are all found in some part of the Muddy Creek series, which is usually considered as equivalent to the coralline. There are altogether twelve species common to the Muddy Creek and Bankivia beds, of which five are recent as well as fossil, and as these five old tertiary species have survived right down to the present day, we may easily suppose that the eight forms which have now become extinct were nevertheless living when the Limestone Creek beds were deposited.

The beds are, as yet, but partially examined, the only collection of shells made being, I believe, my own, and at each visit to the locality I have always succeeded in finding new species.

The actual proportion of living to extinct species is not, however, likely to be materially altered by further explorations. This amounts, so far, to about 95 per cent., and the deposit may therefore be fairly considered as of pleistocene age.

The height of the shell beds at Roscoe's cannot be given exactly, no levels having ever been taken in this part of the country; but approximate aneroid measurements show that they are from 75 to 100 feet above sea level. The bed of the river here is probably not more than 40 feet above sea level, though its waters have so far to travel before reaching the ocean. The tide comes up the stream for about eighty miles, and for this distance there is scarcely any fall. For some miles from its mouth the bed is actually below sea level, as proved by soundings.

Between the river banks and the sea there is no low ground whatever, the fall at the coast being very sudden. The only possible theory, therefore, which can account for this modern deposit is, that Roscoe's and the Limestone Creek flats were in reality an old estuary of the Glenelg, before the land to the south had risen. This estuary was bounded on the east and west by high land, and sometimes by cliffs of coralline limestone, ranging from 70 to 100 feet above the level of the river at that time. Opposite Gilmore's (between Roscoe's and Limestone Creek), a projecting tongue of land extends for nearly a mile into the very centre of the flat, which it divides into two parts for this distance. At the top, it is only a few yards in width, and slopes rapidly down to the terrace on either side, while it maintains throughout the same general elevation as the table land from which it springs, jutting out like a bold headland at sea. Its sharp outline in the midst of this extensive and almost level flat is very striking, and much more suggestive of coast action than of that of a river current. On its sides, the coralline limestone crops out, and the whole ridge consists, no doubt, of harder portions of this rock, which the waters were unable to wear away. These broad flats have thus been formed, partly by the river, and partly by the sea itself, which had access to the estuary, and the shells which were so plentifully strewn on sheltered places under the river cliffs have been since cemented together, more or less completely, sometimes forming a hard rock, and at others a very friable one. In some cases, blocks of the ancient limestone, thrown down from the cliffs, have been encrusted with the shells, which adhere firmly to them. It is not easy always to distinguish between the two rocks, unless a close examination is made, when the older one is seen to contain its characteristic fossils, corals, bryozoa, &c., while in the newer these are, of course, wholly wanting.

The Bankivia beds were most probably laid down during the upheaval, which has raised the whole of the south coast of Victoria, a period of rest occurring while the upper terrace was being formed. Although, as said just now, the great width of the flats here must be in a great measure due to sea action, they were, no doubt, first shaped out by the river itself, as flats of tolerable size are found almost to its source, and amongst very varying strata, a wide excavation having been made in the upper part of its course through slate, sandstone, and even granite. It is most significant that the flats diminish in extent to the south of Limestone Creek, and soon cease altogether, the gorge narrowing so much that for the last 70 or 80 miles of the river's course the opposite banks are seldom more than 300 or 400 yards apart, while the successive terraces no longer appear, the cliffs rising directly from the water's edge. In no part of the river are the banks so widely separated as in the neighbourhood of Limestone Creek. Here, I believe, the mouth of the Glenelg remained for a long period, enabling a vast accumulation of littoral shells to take place. As the land rose, the estuarine deposit was gradually removed farther and farther from the coast, while the river has, in the course of time, cut a winding channel through the flats, and through the ancient limestone farther south, as this gradually emerged from the bed of the ocean.

Art. XVIII.—*The Want of a Uniform System in Experimenting upon Timber.*

By Frederick A. Campbell, C.E.

[Read 9th December, 1886.]

As the strength of timber varies not only according to the tree from which it is taken, but also in accordance with a number of minor conditions which affect it often in a very marked degree, it is evident that unless such conditions be fully and carefully recognised and recorded in connection with any series of experiments upon timber, comparison with other experiments will be impossible, and what otherwise might be valuable work will be rendered almost useless.

The great importance of this subject was impressed upon me very forcibly when collecting information some time ago as to the strength of colonial timbers, and as this interesting field of investigation has as yet been barely entered upon in these colonies, and as much of the work hitherto done suffers from the omission of the details referred to, the present has appeared to me a seasonable opportunity of bringing the matter before this Society, and endeavouring to secure the co-operation of the members in an attempt to introduce some system as a guide for future workers in this direction.

The most important of the minor conditions referred to as affecting the strength of timber are as follow:—(1) Age of tree; (2) nature of locality where grown; (3) part of tree from which timber is taken; (4) length of time seasoned; (5) deflection as affecting the bending moment of a beam; (6) size of piece tested. To each of these conditions I will allude in the order given.

1. *Age of tree.*—In relation to this point, it is only of consequence to know that the piece for experiment has been taken from a tree neither in its earlier nor later stages of existence, for in the former the wood is imperfectly formed, soft, and weak, while in the latter it has entered upon a process of decay; it is in the intermediate or mature stage that the wood is fitted for use practically, and should supply specimens for the purpose of experiment.

2. *Locality where grown.*—The geological nature of the place where the tree grows has a very great influence upon the character of the timber formed. Trees growing in a

moist, low-lying situation will produce, as might be expected, a very different class of timber from that obtained from the same species when found upon a dry and barren ridge. It also appears to me, from a comparison of experiments, that the closer any particular kind of tree approaches equatorial regions the stronger is the timber which it produces. Whether this is a general rule or not I am unable to say, but it would not be unreasonable to suppose that it is so, when it is recollected that the strongest timbers in the world are produced in the tropics, as witness the krangi of Borneo, the ironwood of Burmah, the West Indian mora, and the ironbark of Northern Queensland.

3. *Part of tree from which timber is taken.*—Of the core, the sapwood, and the heartwood, the latter is the only part fit for practical use, and from it, of course, the specimens should be taken. The butt also appears to afford timber of greater density and strength than the top. In pine trees, Mr. Fincham found that the pieces taken from the butt were about nine per cent. stronger than those taken from the top. Whether this holds true as to our own hardwoods it is impossible to say, but still as it is probably a factor affecting the strength of timber, the point should be noted in connection with experiments.

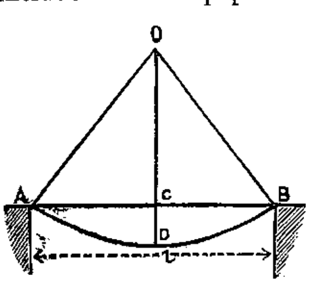
4. *Length of time seasoned.*—The process of seasoning affects different kinds of timber in opposite ways, making some stronger, others weaker. Buffon found that oak timber lost strength in the course of seasoning, and was accustomed to experiment upon it the third day after it was felled. Mr. James Mitchell, on the other hand, finds that blue gum is strengthened by seasoning, as will be shown by the following extract from Baron von Mueller's *Eucalyptographia.* The specimens were 7 feet long and 2 inches square:—

Length of Time Seasoned.	Modulus of Rupture in lbs.
8 months	13,270
2 to 3 years	16,860
3 years	17,670
4 to 5 years	16,970
20 years	20,940

Mr. Laslett, again, in his work upon "Timber and Timber Trees," shows by experiment that the resistance to crushing force in oak is greater when seasoned than when green, but that the transverse strength of different kinds of pine trees is greater when green than when dry.

5. *Deflection as affecting the bending moment of a beam.*—The customary formula for the bending moment of a beam, loaded in the middle and supported at each end, is $\frac{wl}{4}$, where w is the weight applied and l the length of the beam between the points of support. Now this formula expresses the bending moment only so long as the beam retains its original form and position, for whenever deflection begins two new elements are introduced, which affect the result. In the first place, the three forces acting on the beam—viz., the load and the reactions of the supports—cease to act in parallel lines; and in the second place the beam is lengthened by moving over the points of support as it deflects.

Barlow, in his work upon the "Strength of Materials," notices the effect of this new factor, and explains by it what was formerly an anomaly in the behaviour of loaded beams—viz., that the strain increases in a ratio higher than the direct ratio of the lengths. No doubt this is the explanation, for it is very evident that it will require a much less weight to produce the same strain in a beam when highly deflected than when straight. In cases, then, of large deflection the formula $\frac{wl}{4}$ is misleading, and, although sufficiently accurate for ordinary practical use, should certainly be replaced in all cases of experiment by the formula $\frac{wl}{4}$ Sec. $^2\theta$, θ being the angle of deflection. I obtained this result by the simple application of the resolution of forces, and as this method is much shorter and less involved than that given by Barlow, I include it in this paper:—



Let ADB be the beam loaded in the centre with a load w. Let $AB = l$ and θ the angle of deflection. The reactions at A and B will be at right angles to the inclination of the beam at these points, and may be represented by the lines AO BO. Producing the strain in the beam at the point D there is:—

1st, the vertical component of the reaction at the abutments multiplied by the distance at which the force acts—viz.,

$$\frac{w}{2} \times \frac{l}{2} = \frac{wl}{4}$$

2nd, the horizontal component of the reaction acting on the beam as if it were a long column, multiplied by the distance at which it acts—viz.,

$$\frac{w}{2} \tan. \theta \times \frac{l}{2} \tan. \theta = \frac{wl}{4} \tan.^2 \theta$$

and adding this to the former we get

$$\frac{wl}{4} \times \frac{wl}{4} \tan.^2 \theta = \frac{wl}{4} (1 + \tan.^2 \theta) = \frac{wl}{4} \sec.^2 \theta.$$

6. *Size of piece tested.*—It is the practice to assume that the strength of timber as a tie, beam, or column varies according to the sectional area exposed to the strain, in which case the size of the specimens tested to ascertain the strength of any timber, would not affect the result. This, however, does not appear to be the case, for from a comparison of experiments upon large and small scantlings, the results tend to prove, at all events in the case of beams, that the smaller the dimensions of the piece tested the higher proportionately is the moment of resistance.

If any variation were to be looked for, the contrary result might have been expected, for in cutting the wood, fibres which might not run exactly along the line of the piece would be cut through and their support lost, and in small pieces the ratio of the surface to the interior being so much greater than in large pieces the weakening result would be proportionately felt. It might be said, on the other hand, that in small pieces defects would not be so likely to occur, but I do not attach much weight to this explanation, as were this the cause of the anomaly all large pieces tested would require to be subject to these defects in a uniform way and reduced thereby to a corresponding state of weakness, a state of matters highly improbable. Without attempting to explain the reason, I shall simply place on record the facts which seem to establish the proposition.

Tensile strength.—Sufficient data is not obtainable to warrant any conclusions being arrived at with regard to tensile strength, although Laslett, who tested pieces many times larger than any other experimenter, invariably obtained results very much lower.

Transverse strength.—The following table shows results which appear to establish the proposition in question in regard to transverse strength; the most interesting point in which is the difference between the results for ironbark as found by the Engineer-in-chief of N.S.W. and the Railway-bridge Commission on the one hand with 12 in. x 12 in. beams, and Fowkes, Laslett, Tredgold, and Sydney Mint on the other hand, with pieces whose dimensions were 2 in. x 2 in.:—

TRANSVERSE STRENGTH.

Timber.	Scantling.	Mod. of Rupture.	Authority.
Memel Deal	9″ x 6″ x 17′	4,300	Tredgold
	1″ x 1″ x 2½′	9,810	
Baltic Fir	12″ x 9″ x 17′	3,200	Tredgold
	3″ x 3″ x 4′	10,400	
Red Gum	10¼″ x 7″ } x 14′ 8″ 11½″ x 8½″ } x 14′ 8″	8,800	Vict. Rly. Dept.
	2″ x 2″ x 2′	11,700	Mueller
British Oak	8·57″ x 8·57″ x 10′ 8½″	9,130	Barlow
	7·50″ x 7·50″ x 10′ 8½″	9,280	Barlow
	6·43″ x 6·43″ x 10′ 8½″	8,680	Barlow
	5·35″ x 5·35″ x 10′ 8½″	9,530	Barlow
	4·28″ x 4·28″ x 10′ 8½″	9,550	Barlow
	2″ x 2″ x 6′	10,800	Laslett
Ironbark, N.S.W.	12″ x 12″ x 26′	13,953	Engr. chf. N.S.W.
	12″ x 12″ x 29·6′	12,222	Rly. Bdgs. Comn.
	2″ x 2″ x 4′	18,000	Sydney Mint
	2″ x 2″ x 1′	18,000	Fowkes
	2″ x 2″ x 7′	22,000	Laslett
	2″ x 2″ x 1′	24,100	Tredgold

Resistance to crushing.—Here comparisons are impossible. Barlow considered that the strength increased in a higher ratio than that of the area, whilst Tredgold took the opposite view. A series of experiments upon sets of blocks of varying area carried out by some one person would be the only way to settle the question satisfactorily.

These are the six minor conditions which it is necessary to record in connection with any series of experiments, in addition to which, of course, the particular species of timber to which each piece tested belongs must be thoroughly established. Local or popular names are almost valueless for the purpose; the true botanical nomenclature must be used. Some of the most extensive series of experiments carried out in Britain and in these colonies fail lamentably in this respect, and work which must have taken much time, and cost much money, is thus seriously diminished in value. As far as the work of experimenting itself is concernèd it should embrace the following lines of inquiry, and in each case should be made upon timber both in its green state and when seasoned:—Weight, resistance to crushing along and across the grain, tensile strength, transverse strength, elasticity, resistance to shearing along and across the grain, and durability.

In view of the early establishment in our University of a complete testing machine, it is to be hoped that the coming year may see some good and systematic work done in the direction of timber testing. This should not prevent others, however, who have no apparatus from assisting in the work, for the more numerous the experiments the nearer to the truth do we arrive. All that is necessary is the inclination for the work, coupled with care and patience in carrying it out. The roughest bushman in the interior, breaking a few sticks with weights, and telling us all that is to be known about these sticks and about these weights, adds to the knowledge of the world, and his rough work, if only careful, true, and full, may rank with that of high officials who work in dockyards or laboratories with perfect machines and paid assistants. He may even rank before them as a benefactor if his work be complete, theirs imperfect, in the respect that complete knowledge, however limited, is truth, and is established for ever, whilst imperfect knowledge, however extensive, may only lead us into error and confusion.

ART. XIX.—*The Tripolite Deposits of Lilicur.*

A MONOGRAPH, BY F. M. KRAUSE, F.G.S.

[Read 9th December, 1886.]

ALTHOUGH the occurrence of randanite in the neighbourhood of Talbot was made known through hand specimens more than twenty years ago, there has been hitherto a seemingly insurmountable difficulty in fixing the precise locality, while no information whatever could be obtained respecting the extent and mode of occurrence of the deposit. Recently some fresh discoveries were announced, and within the last month (September, 1886) samples have been sent to the School of Mines, Ballarat, from four or five different places, described as being situate between Clunes and Eddington. As the several specimens bore in their composition and structure a marked resemblance to each other, the suggestion was hazarded that a connected seam of this mineral would probably be found to spread from Stony Creek to the Loddon—a meridianal distance of upwards of twenty-six miles. Naturally, such an extent would bespeak for the deposit a marine origin, an assumption which is, however, contradicted by the otherwise well-understood physiography of the district. A closer examination of the actual features in connection with the occurrence of these randanite beds seemed to me the more desirable, as, apart from its geological aspect, the question has a not-unimportant practical bearing from the economic value attaching to the material itself.

The tract of country selected by me for examination lies between the village of Lilicur, on the Bet Bet Creek, and the western watershed of the Daisy Hill Creek, five miles westerly of Amherst, and is particularly favourably conditioned by reason of the numerous sections, both natural and artificial, which it affords.

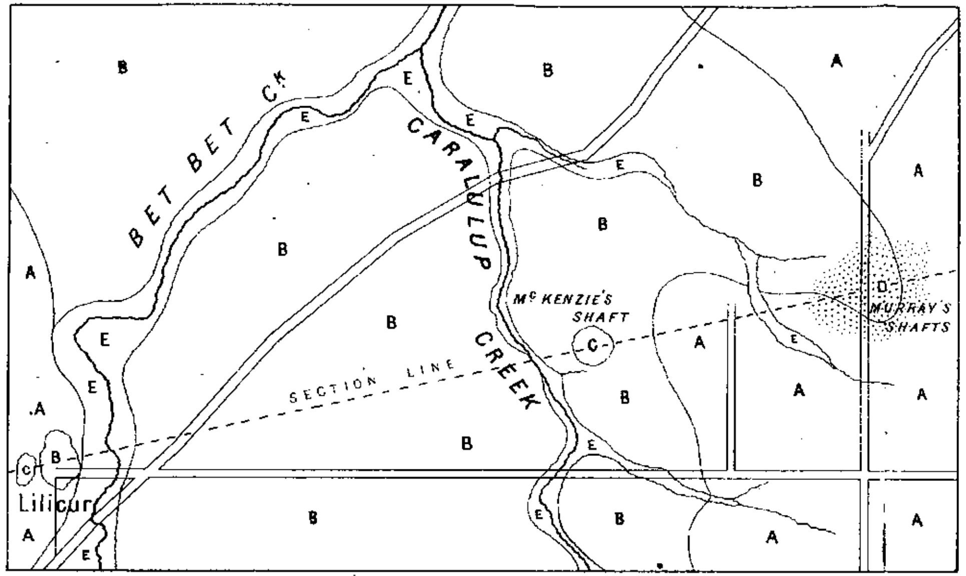
For the better understanding of the local conditions under which the randanite deposits were formed, and before entering into a description of the actual features observed, it will be well, perhaps, to state briefly what is known of

GEOLOGICAL SKETCH MAP OF PART OF LILICUR - COUNTY OF TALBOT

Index

A Lower Silurian B Newer Volcanic G Tripolite deposits

D Upper Pliocene capping E Post Pliocene

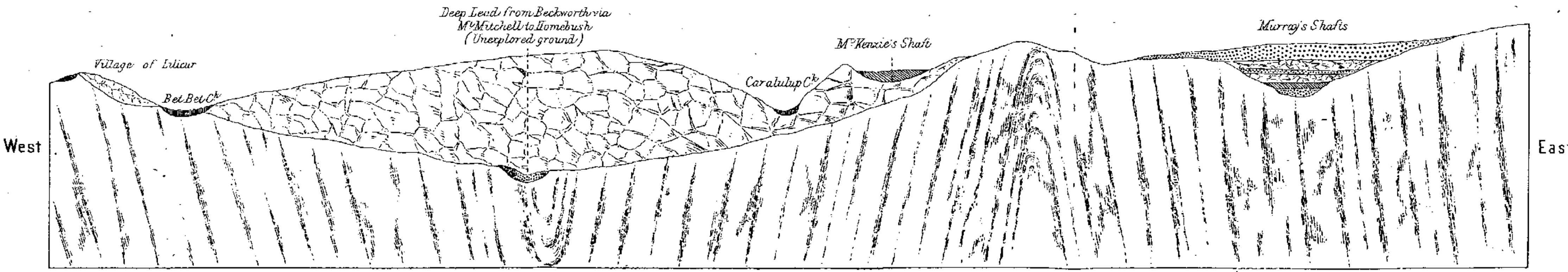


Scale.

40 chains to 1 inch

GEOLOGICAL SKETCH SECTION FROM LILICUR TOWARDS AMHERST

Section Line N. 78° E. 2¾ Miles



the nature of similar diatomaceous deposits generally. Considered from a mineralogical standpoint, the Lilicur material agrees with the variety *Randanite* of the Auvergne, in France—*i.e.*, it is an opal, consisting essentially of hydrated silica, with about 6 per cent. of alumina and lime. As a rock-forming substance it is known by petrologists as *tripolite.* Examined under the microscope, it is found to be almost entirely made up of the frustula of diatoms. The more familiar name, "*infusorial earth,*" implying, as it does, a zoogenic rock, was given under a misapprehension of the true nature of the organism of those microscopic bodies.

Diatomaceæ, or *bacillaria,* form a suborder of the thallophyta unicellularia, and may be concisely characterised as single-celled algæ with silicious valves. They are aquatic plants, thriving alike in fresh, brackish, or salt water; under the Equator, or in the Polar regions; on the bed of the ocean, under a covering of 27,000 feet of water, or ice-bound among the glaciers of the highest mountains. The individual diatom is constructed of a germ nucleus, surrounded by a watery plasma, which is contained within a silicious envelope. Propagation takes place by partition along the centre of the nucleus and the entire cell. The period during which the diatom remains in an undivided state has been variously estimated at from six to forty hours; taking twenty-four hours as the average, it will be seen that a single diatom is capable of multiplying to the extent of upwards of a thousand million within the space of a month.

On the death of the plant the empty frustules fall to the bottom of the basin in which it grew. Here, being mainly composed of silica, and therefore practically unaffected by decomposition, they accumulate, building up layer upon layer, often over considerable areas, and, under favourable conditions, actually filling up the entire space within the basin originally occupied by water.

The number of species of diatoms known exceeds 1500, and although the forms of some fresh-water genera bear a close resemblance to others of brackish, and even salt-water habitats, it is often possible to judge from the type of diatoms present whether a tripolite is of fluvial, lacustrine, or submarine origin. It can be easily conceived that in a lacustrine deposit, especially if the lake had no regular inlet (as those of Lilicur), the distinct genera are likely to be few in number, and often endemic, while an estuary or submarine bed would generally contain a large variety of both genera and species.

Diatomaceæ make their first appearance in specific areas of the Upper Chalk, increasing thence during Tertiary times, and gain their widest distribution, as well as greatest abundance, at the present day, many of the fossil species being identical with those now living.

Tripolite occurs in many parts of the globe, the most noted deposits being those of Tripoli, on the Mediterranean (whence the name); Mount Amiata, in Italy; Franzenbad, in Bohemia; and Richmond, in Virginia. The Richmond bed is described as the most extensive of any yet examined, its thickness being 40 feet.

In travelling between Creswick and the Loddon an observer will not fail to mark the occurrence, over an otherwise level tract, of numerous shallow depressions, varying in area from a few perches to a hundred acres and more—now isolated, and again clustered together in twos and threes or dozens within a square mile. Although more extensively existing on volcanic lands they are not absolutely confined to them, as they are occasionally met with on the clay drifts, which usually in this district fringe the lava sheets, as well as on neighbouring Silurian flats. On closer inspection we find that these depressed areas do not present a uniform appearance, for, although they are all covered with water during the greater part of the year, there are some which support a rankness of reeds and coarse grass, while others are free from vegetable growth, and even the scanty bottom layer of humus appears to be entirely deprived of organic matter. In the latter instance we invariably find on the floor and around the margin of the basin a deposit of bog iron ore (earthy limonite). In the marshy pools this ferruginous deposit is absent, although it is evident that there must be an abundance of hydrous peroxide of iron eliminated by the disintegration of the basalt. We have here a good example of the deoxidising action of humic acids generated by decaying vegetable matter. In the other case this deoxidising process has either never taken place, or, if formerly active, has now ceased. The hydrous ferric oxide is precipitated, and, mingling with particles of clay and sand, produces those earthy ironstone sappings and pebbly concretions so common on many parts of the plain. These deposits are still in progress of formation, and in course of time will, no doubt, completely obliterate the corrugations which at present mark the face of the land.

The topographical features at the close of the Pliocene period appear to have been, in many respects, analogous to those just described. The lava of Lilicur and Caralulup has been, in part at least, derived from Mount Mitchell, whence it descended, and by successive sheets filled a then existing river valley, the lower portion of which is now known to us as the *Homebush auriferous lead.* During and subsequent to these lava flows the surface of the country was in places pitted by shallow basins, which became harbours of bacillaria and receptacles for their frustules. Owing to the trifling extent and gentle slope of the area drained by the individual basin, the effect of erosion was exceedingly slight, and the amount of foreign sediment that was washed into the basin so minute as to be imperceptible. Nevertheless, in view of the eminently ferruginous character of the surface rock, the absence of ochreous matter in the body of the tripolite is noteworthy. The circumstance explains itself when it is borne in mind that a reducing agent in the form of humic acid was unquestionably produced by the decay of the organic parts of the diatoms themselves, and that this production was probably sufficiently copious to prevent, without the aid of other agencies, the settlement of any ferric oxide that may have entered the pool.

The principal tripolite bed in the district, as far as it has been explored, is that situate on Mr. M'Kenzie's farm, on allotment 15, section I, parish of Lilicur. The deposit completely fills a basin-shaped hollow in the basalt, the maximum depth being 17½ feet. The surface is level, and the contour, somewhat circular, with a mean diameter of about 500 feet, encloses an area of, approximately, 4½ acres. The quantity of tripolite in this basin (calculated from the above dimensions) is 1¼ million cube feet, which, taking the specific gravity at 1·91, represents a bulk of 66,500 tons. A shaft has been sunk near the centre of the deposit on to the bed rock (a highly vesicular basalt, in places reduced to a warke), and from it galleries have been driven in various directions along the basalt floor, which is remarkably even, and has a slight outward rise. The deposit itself has a tolerably horizontal—albeit somewhat waviform—stratification, and although strictly homogeneous in its structure, and of uniform snowy whiteness, the laminæ (more correctly speaking, the layers of growth, varying from half an inch to three inches in thickness, and extending from floor to roof) can be traced for many yards along the walls of the galleries and to every point of the compass. The general uniformity in the texture and colour of the deposit is broken here and there by dark-stained, sharply-defined bands and veins, the origin of which is due to desiccation and subsequent infiltration from above. Where the desiccation cracks were of sufficient width (from 1 to 2 inches) they have been filled by a brownish black clay, and then stand out in harsh contrast to the downy clearness of the surrounding silica. In other places the contracting mass has been rent by mere capillary joints, along which percolating waters have caused a partial solution of the silica, and its ultimate resolidification into a colloid form. This process is still going on, and the result is an occasional band or recticular patch of opal of a waxy lustre and pale yellow colour. The specific gravity of the pure tripolite is 1·908, that of the opal 2·008.*

It has been already suggested that this and similar lakes had no inlet, properly so-called, but that its contents were derived from the meteoric waters falling within its own narrow drainage area. Had any extraneous organic substance been carried into the pool, and there commingled with the diatoms, traces in the form of carbonaceous or bituminous matter must have remained, and would now be easily recognisable in the white silicious stratum. In the absence of any such traces, it must be inferred that there was an overflow channel through which any floating matter was removed. In reality there was such an outlet, for along the existing gully, which runs past the southern edge of the deposit into the Caralulup Creek, cake-like patches of tripolite can be traced under the turf nearly the whole distance to the valley of the main stream below.

About three-quarters of a mile to the east of M'Kenzie's mine, there are two shafts, not now accessible, but respecting which the following information has been supplied by Mr. Murray, who sank them:—The southern shaft went through a layer of tripolite 2 feet thick, and of similar appearance to that found at M'Kenzie's, after sinking through 40 feet of clay drift. The second shaft, which lies a few chains north of the former, is 75 feet deep, pierced two layers of basalt, and *beneath* them a bed of tripolite 18 inches thick.

Immediately to the north-west of the village of Lilicur, and close to the western edge of a basaltic outlier, fragments

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* As determined at the School of Mines laboratory.

of tripolite are to be seen turned up by the plough-share from under the turf, which rests upon Silurian slate.

The occurrence of tripolite in these two situations shows that the remains of diatoms had there already accumulated prior to the lava flows, while those on the high ground above the Caralulup Creek were deposited subsequently. The accompanying plan and section show the relative mode of occurrence of the several tripolite deposits, as well as illustrate the general geological structure of the locality.

The diatoms which make up the tripolite of Lilicur are principally of the three well-known forms—Pinnularia (P. viridis), Navicula, and Synedra. In addition there is a great abundance of small parallel-sided and oval-ended hollow bodies, which, but for the absence of the characteristic longitudinal furrows, might be mistaken for Baltryllium. The first three genera are denizens both of fresh and salt water, and their presence would not, therefore, by itself define the geological position of the deposits. Enough, however, has been observed and herein noted to warrant the statement, on physical grounds, that the Lilicur beds are fresh-water lacustrine formations of Upper Pliocene or Pleistocene age.

BALLARAT, 1*st October*, 1886.

1886.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

[N.B.—The remarks and speeches in the discussions are taken down verbatim by a short-hand writer, and afterwards written out at length with a typewriter, for reference and reproduction, if required, and therefore more is seldom given herein than an indication of their general drift. If any person should wish to refer to the verbatim report, he can apply to the Secretary to the Society, who will give him an opportunity of perusing and copying it; or if he reside at a distance, so much as he requires will, upon payment of the cost of reproducing it, be forwarded to his address.]

ANNUAL MEETING.

March 11*th*, 1886.

PRESENT, the President (in the chair) and 16 members and associates.

The Report of the Council and Balance-sheet for 1885 were read and adopted. (See volume XXII., pp. 145-9).

The retiring officers, with the exception of Mr. Sutherland, who resigned the office of Honorary Secretary, were re-elected; and Mr. H. K. Rusden was elected Hon. Secretary.

The meeting then resolved itself into an ordinary meeting, and the minutes of the last ordinary meeting were read and confirmed.

Dr. M'Gillivray's "Description of New, or Little-known, Polyzoa, Part X.," was accepted as read; and Mr. A. Sutherland read a paper by the Rev. D. Macdonald (of Fate, New Hebrides) on "The Oceanic Languages Shemitic."

April 8th.

Present, the President (in the chair) and 27 members and associates.

Mr. John Dennant was duly elected by ballot a country member of the Society.

The PRESIDENT (vacating the chair, which was taken by the Hon. Librarian, Dr. Neild) read Mr. Campbell's paper on "The Stability of Structures in regard to Wind Pressure."

Dr. IFFLA would have liked to see a larger collection of recorded maximum pressures. The great discrepancies shown in those produced indicated the need of more extended observations.

The PRESIDENT said that anemometers were often destroyed by the excessive pressure.

Mr. M'LEAN mentioned a simple method and apparatus for testing wind pressure.

Mr. RUSDEN thought the imperfection of the records arose from the limited width of the most violent currents or gusts of wind and the paucity of anemometers.

Mr. SUTHERLAND agreed, and doubted whether the most violent gusts were ever properly recorded by anemometers.

The PRESIDENT could not credit the records, which appeared to him impossible. If they were correct, railway carriages would be frequently blown over, and, in fact, would require 50 tons of ballast or a gauge of 20 feet.

The PRESIDENT read a letter of apology from Mr. Griffiths (who was to have read a paper that evening) for unavoidable absence in Sydney.

Mr. SELBY, in another room, exhibited and explained the action of Crooke's Radiant Matter Tubes.

May 13th, 1886.

Present, the President (in the chair) and 16 members and associates.

The following gentlemen were duly elected by ballot as members of the Society:—The Hon. F. T. Derham, M.P., and Messrs. Arthur Lynch and A. C. Wannon.

Also as associates:—Messrs. R. W. Chapman, James T. Cole, and Sydney Horsely.

The PRESIDENT called attention to the handsome present made by Mr. Selby to the Society's Library, of Alexander Von Humboldt's *Vues des Cordillères*, original edition of 1810, and of Boscovich's *Opera Astronomica*, in 5 vols.

A vote of thanks was accorded to Mr. Selby.

Mr. G. S. GRIFFITHS read his paper on "Evidences of a Glacial Epoch from Kerguelen's Land, being Comments upon the 'Challenger' Reports."

The PRESIDENT recognised the subject as both interesting and important, and invited discussion.

Mr. GRIFFITHS said that he had had in view the fact that England and Germany were said to be contemplating further Antarctic exploration, and he thought a party should be sent there for two or three years to make scientific observations.

BARON VON MUELLER had discussed the subject at a meeting of the Geographical Society, and he suggested the establishment of a station for scientific observations at Macquarie Island; also, that Australia should contribute towards Antarctic exploration.

Mr. ELLERY had been interested in Mr. Griffiths' account of the rainfall at Kerguelen and other islands. He had learned something of the region from the late Captain Kay, who had been there in Ross' expedition, and of the island south of New Zealand from Mr. Musgrave, of Cape Otway lighthouse, who had been wrecked there and made some useful observations. The Antarctic climate is suspected to be not nearly so severe as is commonly imagined, because warm deep-sea currents are known to exist there.

After some further remarks from the same gentleman and Mr. Marks,

Mr. A. C. MACDONALD proposed that the Royal Society and the Geographical Society should appoint a joint committee of three members each to inquire into and report on the subject generally. This was seconded by Baron von Mueller, and carried, on the understanding that the selection of the members of the committee should be left to the Council.

Mr. ELLERY said that self-registering instruments could be left on Antarctic land, which would obviate to a great extent the necessity for a party residing there through the winter.

BARON VON MUELLER then read a paper on "Plants Collected by Mr. H. S. King in Capricornic West Australia," of which he produced specimens.

The PRESIDENT acknowledged the great interest and importance of the contribution to knowledge.

June 10th.

Present, the President (in the chair) and 21 members and associates.

The following gentlemen were elected by ballot members, &c., of the Society:—D. M. Davies, Esq., M.L.A., as a country member; and Messrs. F. E. Jackson, Richard Matthews, and Dr. J. J. Wild, as associates.

The PRESIDENT announced that a large number of scientific journals had been received by exchange and donation, also Vol. XX. of the *Encyclopædia Brittanica.*

The PRESIDENT read a letter from the Secretary to the Geographical Society, notifying the appointment of Baron von Mueller, Captain

Pasco, R.N., Dr. Bride, Dr. Wild, and himself, as members of the proposed Joint Antarctic Committee; and he also reported that the Council of the Royal Society had appointed as members of the same committee, himself, Mr. Ellery, Mr. Griffiths, and the two secretaries, Mr. Rusden and Mr. Selby. The new committee had already held one meeting.

Mr. Rusden then read Mr. Wakelin's paper "On the Possibility of the Force Producing Gravitation not Acting Directly on every Particle of a Planet."

The President said the subject was intricate and difficult, and, though frequently attacked, remained so far unsolved. The paper seemed hard to comprehend, but he invited members to discuss it.

Mr. Ellery said Mr. Wakelin had before suggested experiments with a special spring to find whether bodies weighed more or less on the side of the earth nearest to or farthest from the sun, but he failed to see the utility of them.

After some remarks from Mr. White and Mr. Steene, Mr. Ellery suggested that the paper be printed, so that members might all read it before discussing it. This was seconded by Mr. White and carried.

The Secretary then read Mr. F. A. Campbell's paper on "The Stability of Structures in regard to Wind Pressure (No. 2)—Bridges."

Mr. Ellery said that he had constructed an anemometer for recording momentary gusts of wind, the results of which were scarcely credible. Wind is not a moving mass, but moves in eddies and gusts, which are extremely local, and usually escape record.

Mr. Griffiths thought the general velocity of a wind furnished no indication of its occasional local violence. He compared with it a stream of water, the velocity of which is known to vary in every part of a section of its channel. He suggested the indefinite multiplication of wind gauges.

Mr. Rusden, Mr. White, Mr. Steane, and Mr. Ellery corroborated the views expressed.

The President quoted from a report from Mr. Waddell, an American engineer in Japan, who stated that American engineers commonly made sufficient provision for wind pressure. Since the Tay disaster excessive allowance had been made for it in England. The American practice has been endorsed by Mr. Baker, President of the mechanical section of the British Association. Americans reckon that a pressure of 30 lbs. to the square foot being sufficient to overturn a railway carriage, it is useless to make the bridge resist more. American bridges stand well on this principle, and it looks like waste to allow for 60 lbs., as is done here and in South Australia.

July 8th.

Present, the President (in the chair) and 17 members and associates.

The Librarian produced the first number of the *Journal of the British and American Archæological Society of Rome*, with a letter proposing to exchange publications, which it was agreed to do.

The President read a letter from Professor Foster, Secretary of the Royal Society, London, respecting the proposed affiliation with that Society, and acknowledging the letter from this Society, dated 26th February.

The President invited discussion upon Mr. Wakelin's paper now printed and circulated.

Mr. Ellery found the subject very difficult and obscure, and was not prepared to enter upon it.

Dr. M'Gillivray's "Descriptions of New, or Little Known, Polyzoa, Part XI.," was accepted as read.

Mr. Griffiths presented a memorandum, prepared by the Joint Committee on Antarctic Exploration, showing the advantages to be derived therefrom. This had been widely circulated.

Conversation ensued, in which Mr. Ellery, Mr. White, and others took part, and in which it transpired that, though whale oil is not now so much in demand as formerly, whalebone had risen to £2000 a ton. The commercial view of the question was therefore becoming important.

Mr. Ellery then produced Dr. R. D. M. Verbeek's report (French translation) on the Krakatau eruption, which he had just received from Mr. Ploos van Amstel, whom he introduced to the President. Mr. Ellery also produced some geological and other specimens of the ejecta. He mentioned Professor Milne's (of Tokio) theory of the profile of volcanic mountains, furnishing a basis of calculation of the specific gravity and character of the rocks composing their structure.

Mr. Ploos van Amstel said he was very glad to be able to serve the Society, and could say the same for Dr. Verbeek.

Mr. Ellery moved that the Council be requested to take the necessary steps, under clause 24, to elect Dr. Verbeek an honorary member, and that was agreed to.

The President suggested a probable connection between the outbreaks at Krakatau and Tarawera, and of both with the reported extinction of the volcano of Kilauea, in the Sandwich Islands.

Mr. Griffiths added some remarks as to the forms of volcanic mountains being indicative of their geological composition.

The President notified the engagement of Dr. Wild as assistant secretary to the Society.

August 10*th*.

Present, the President (in the chair) and 22 members and associates.

Mr. William Lucas and Mr. Gerard White (hitherto associates) were duly elected by ballot as ordinary members of the Society.

The PRESIDENT read a letter from Mr. Bowrie, collector of customs at Invercargill, stating that the Auckland, Campbell, and Macquarie Islands are periodically visited by a New Zealand Government vessel, and promising a report upon them, on its return from its present trip.

The PRESIDENT, vacating the chair, which was taken by Mr. Ellery, read his paper "On Lightning Conductors."

Mr. ELLERY quite agreed with the paper, and gave illustrations of the great want of knowledge on the subject of lightning conductors. He had been asked by the Government to report upon the safety of the powder magazine at Maribyrnong, which had been represented by the military authorities as in danger because the conductors were not insulated. When the magazine was erected, several years ago, he prepared the plans, and accordingly it was thoroughly protected by a complete network of conductors connecting the copper, iron, and lead work all over the building in a continuous chain, terminating in a long band of copper leading to the Saltwater River. He described the precautions successfully adopted in Munich to protect it from thunderstorms, from which it had formerly suffered frequently. He recommended a similar system for Melbourne. He described the effects of disruptive discharges of lightning as observed in two recent instances, at Gabo Island lighthouse, and at a house in South Melbourne. In the latter case the high conductivity of a heated column of air in a chimney was clearly shown. He expounded the theory of the electric condition of the earth and of the atmosphere in thunderstorms, and described experiments which he had made to ascertain the position of the equipotential lines in the vicinity of a building under various conditions of the weather, and the electric tension between the strata of negative and positive electricity. These proved the necessity of protecting every salient point of a building by a conductor.

Mr. J. J. THOMPSON described experiments which he had made with an insulating rod during two years.

After further remarks from Mr. Ellery, Mr. Campbell, and the President,

Mr. ELLERY moved that the rules for the erection of lightning conductors drawn up by the conference, representing the Meteorological Society, the Royal Institution of British Architects, the Physical Society, and the Society of Telegraph Engineers, which met in London in 1878-1881, be reprinted and circulated for public information by the Royal Society. This was seconded by Mr. Sutherland, and carried unanimously.

Mr. GRIFFITHS moved that the discussion upon the Tarawera eruptions be postponed till next meeting. This was seconded by Mr. Rosales, and carried.

The PRESIDENT then asked Mr. Lucas to read Mr. W. M. Bale's paper, entitled "The Genera of the Plumulariidæ, with Observations on Various Australian Hydroids."

Mr. LUCAS read an abstract of the paper, and, after a few remarks from some of the members, the proceedings closed.

September 9th, 1886.

Present, the President, Professor Kernot, M.A., C.E. (in the chair), and 30 members and associates.

Mr. WALTER E. T. POWELL, of Goode Island, Queensland, was duly elected by ballot as a country member.

The PRESIDENT announced that the Council of the Society had recommended Dr. R. D. M. Verbeek, of Buitenzorg, Java, as an honorary member of the Society, under clause 24 of the laws of the Society.

Dr. VERBEEK, having been duly nominated by Dr. Jamieson and Mr. Arthur Lynch, was unanimously elected by ballot an honorary member of the Society.

The PRESIDENT called on Mr. G. S. Griffiths to read his paper "On the Official Reports of the Tarawera Eruption." Accepting the official description of the occurrence, he disputed the conclusions arrived at. He thought it was incorrectly described as a purely hydrothermal phenomenon, and as a merely local movement; and alleged that the chemical composition and plutonic nature of the ejecta were inconsistent with such a conclusion.

Captain F. C. ROWAN had just returned from New Zealand, where he had heard from Dr. Hector a more detailed description of the eruption and fuller reasons for his conclusions. He thought that until the complete report had been received it was premature to criticise the instalment of it which had come to hand.

The PRESIDENT reported some observations made by himself at Vesuvius on the periodicity of the puffs of steam twice in a minute. A similar periodicity in the emission of steam had been observed in other active volcanoes.

Mr. LUCAS questioned the correctness of the chemical composition attributed to the ejecta, which he considered andesitic rather than obsidian. Only surface and light materials having been ejected, favoured Dr. Hector's view of the eruption not being deep-seated. He did not think that generation of steam was an indispensable cause of volcanic eruptions.

Mr. THOMPSON remarked on the general proximity of volcanoes to the seaboard, and inquired as to the local geology at Tarawera.

Dr. RALPH showed Mr. Percy Smith's map of Tarawera.

Mr. WHITE remarked that explosions were not always accompanied by low atmospheric pressure.

After some remarks from Mr. Selby and Mr. Lynch, Mr. Griffiths replied to the various speakers, and the proceedings terminated, Mr. Howitt's paper "On the Intrusive Rocks of Dargo" having been postponed till next meeting.

October 14*th*, 1886.

Present, the President, Professor W. C. Kernot, M.A. (in the chair) and 20 members and associates.

The President announced that Mr. Hunt, of the Royal Mint, Sydney, had accepted the appointment of delegate of the Society at the preliminary meeting for the purpose of forming an Australian association for the advancement of science.

Also the receipt of sundry communications on the subject of Antarctic Exploration from the Scottish Geographical Society and the Otago Institute, New Zealand.

Also that the annual conversazione had been fixed to take place on the 26th inst., and that a committee had been appointed, consisting of Messrs. Ellery, Griffiths, Jamieson, Josephs, Kernot, Murray, Rusden, and Wild, to make the necessary arrangements.

The President then asked Mr. Selby to read Mr. A. W. Howitt's paper, entitled "Notes on the Area of Intrusive Rocks at Dargo." Mr. Selby read the paper accordingly, and it was then discussed by Mr. Griffiths, Mr. Thompson, Mr. Lucas, and the President.

Mr. Lucas then read a paper, entitled "On the Sections displayed in the Coode Canal," and another "On the Sound Organs of the Green Cicada." After some discussion, the meeting closed.

On Tuesday, the 26th October, a conversazione was held by the members of the Royal Society in the new Masonic Hall, Collins-street East. His Excellency and *aides-de-camp* were received in the vestibule by the President and Council. The President delivered his address (which is prefixed to this volume), in which he gave a retrospect of scientific progress during the year.

Mr. Griffiths then read an address on "Antarctic Exploration," and exhibited a picture in water colours of Captain Weddell's schooner the "Jane," in south latitude 74 degs. 15 mins., 36 degs. long. W., in 1823, which he had been fortunate enough to obtain for the occasion. He said:—Fourteen navigators have attempted Antarctic exploration, and all we know of the region is due to their enterprise. Its chief physical features are three great promontories, or north-stretching land masses, three great bights, and three great ocean currents. The latter originate within the tropics, and terminate in the bights. There the warm waters of these currents melt the ice, and leave openings for exploratory work. The ocean around the Pole averages over two miles in depth, and its bed is barred by several well-defined deposits. The blue mud is peculiar to the neighbourhood of continents, and its presence along the ice barrier indicates a Polar land mass, even where, as yet, land has not been seen. The sea teems with animal and vegetable life. Whales are plentiful. Whether any plants or animals exist upon the Antarctic land there has been no opportunity of ascertaining. The dredge has disclosed the occurrence of granite, metamorphic, and plutonic rocks, sandstone, limestone, and shale. The climate is believed to be cooler than the Arctic in the summer, but less cold in the winter. The sea ice differs from that of the Arctic, the bergs being more massive, but the pack ice less extensive. With regard to the further information desired, it is set forth in the memorandum of the objects to be served by Antarctic exploration, which this Society assisted to prepare and publish, and which can be obtained by application to the Secretary. To obtain this knowledge two schemes are under consideration, one by societies in England, the other by ourselves. The Imperial scheme will involve sending out two ships for a three years' cruise. That expedition will be under naval discipline, and will be devoted exclusively to scientific discovery. Its cost will probably exceed £150,000, and must therefore be left to the mother country. Our scheme is more modest, but we believe that its observations will prepare the way for the other. Dundee and Peterhead yearly send to the Arctic Sea a fleet of steam whalers, strongly fortified to battle through the ice-encumbered straits which lead up to the great fishing grounds. These vessels are admirably adapted to serve our purpose, and we have, through our Government, asked what will induce their owners to send one or two ships to fish in the Antarctic seas, taking two or three observers as passengers, and giving them every facility, compatible with the ship's business as whalers, for gaining a knowledge of the region. Now, we know from experience that whaling and scientific observation can be carried on together without difficulty. The "Enderby's" whalers managed both admirably in these very waters fifty years ago, and the names of the firm, of their masters and their ships, will be remembered for their geographical discoveries when the repute of the firm as British shipowners has been forgotten, and their labours prove that high-class scientific work has been well performed by busy whalers themselves during hours saved from their laborious calling. There is reason to hope that a Scotch shipowner will be satisfied with a bonus of, say, £2000. If such a hope should prove to be well based, surely Victoria will not allow the project to fail for want of such a paltry sum. The scientific results to be achieved by such an expedition might not be complete and exhaustive; but they would be of great value, and their attainment is within the compass of our means. Despatched early in the season, it would discover the winter condition of these seas, the position of the edge of the pack ice, and the time of its breaking-up; and it could follow up the early-formed leads, and reach a high latitude early in the season, and make valuable discoveries in the open water along the land. We have already several offers from leading shipowners in Scotland of some of the finest steam whalers in the world. We do not know the exact terms upon which they can be got, but we expect to learn them soon.

Mr. ALEXANDER SUTHERLAND also read a paper on "Allotropy," illustrated by experiments.

The numerous assemblage of ladies and gentlemen then inspected the various exhibits shown by sundry members of the Society, and proved their sustained interest by protracting their examination till a late hour.

The following were the principal articles exhibited :—Mr. G. W. Selby showed Sir W. Thomson's astatic mirror galvanometer, quadrant electrometer, and dead beat galvanometer; Obach's tangent galvanometer, and an instrument for producing electric jewels; electric bridge by Elliott Brothers, and portable irresistible electric miner's lamp; Crooke's radiant matter tubes, thermo-electric pile; Deprez and D'Assonval's dead beat galvanometer, and a standard condenser.

Mr. LUCAS showed a table of microscopes, with series of biological slides and histological apparatus, from Trinity College Biological Laboratory.

Mr. FORBES-LEITH exhibited a group of pigmy flying phalangers, family phalangistidæ, order marsupialia, genus acrobates, species pygmæus.

Mr. H. T. TISDALL showed four groups of coloured drawings of Fungi, Agaracini, Polyporei, Clavarici, Tremellini, Myxogastres, Sphœrici, Peziza, &c., and a coloured drawing with section and specimens of a curious polyporus growing on a Mylitta Australis.

Mr. C. W. OTTO exhibited two electric clocks.

Mr. C. W. M'LEAN exhibited one centrifugal pumping engine, one blowing engine for No. 2 Customs Launch, and one small hydraulic portable rivetter from the Tyne Foundry.

Mr. FRENCH exhibited a collection of Australian and Exotic Buprestidæ, Longicorns, and Lepidepteræ, including the new Beetles Ratocera Frenchii, Etryoptera Frenchii, Rosenbergia Melanocephala, and Phalacrognathus Muelleri.

Mr. JOSEPHS exhibited for the Torpedo Corps (1) Watkin's depression position finder, and (2) new circuit-closing apparatus, with relay, for electro contact mines.

Mr. J. E. SHERRARD exhibited two formicaria, two marine aquaria, with specimens of Old wife (Enoplacus armatus), Hermit Crab (Cenobito Diogenes), Porcupine fish (Diodon Histriæ), Flounder (Pleuronectes Victoriæ), and one fresh water aquarium, with specimen of Japanese Salamander (Siebolda maxima).

The following exhibits were contributed by Mr. Smibert and Mr. Quarry, of the General Post Office :—One Deprez D'Assonval reflecting dead beat galvanometer, with transparent celluloid scale; standard Wheatstone bridge, post-office form; Deprez galvanometer (combination ammeter Vollinder); Siemen's universal galvanometer; Blackburn portable testing apparatus (range ·005 to 2000 Ohms.); metre bridge with low resistance, reflecting galvanometer; new form of Wheatstone bridge (resistances plugged in); portable lightning rod tester, with magnet generation; Warner's battery gauge (for single cells); Ayrton and Perry's spring ammeter (long range); Ayrton and Perry's spring voltmeter (medium range); Miller's low reading ammeter (for single cells); Carden's voltmeter; E. P. and Storage Co.'s ammeter (for storage battery); Farquharson and Lane, electric speed meter; Consolidated Co.'s telephone transmitter; Hunning's long distance transmitter; Etalon acoustic or mechanical telephone; small telephone exchange, office form; Regnier's accumulator, with incandescent lamps in circuit; chloride of silver battery, 100 cells (portable); watchman's tell-tale, American form; collection of glow lamps—Swan, Edison, Lane, Fox, Bernstein, and Opperman; collection of aërial and underground telephone cables.

Mr. Davidson exhibited plan of Yan Yean system and extensions, and fine photographs of principal works.

Professor Andrew exhibited a hydraulic pump, &c.

Mr. Fenton, Fuller's slide rule.

Mr. Warren, a galvanometer.

Messrs. Metzler & Co., surgical instruments.

Professor Kernot, seventeen photographs of locomotives on the principal railways of England, five of railway bridges in South Australia, and two of the recent railway accident at Bridgewater, Tasmania.

The Amateur Photographic Society, some fine photographs, and from the Natural History Museum, two skins and eggs of the ornithorynchus paradoxus.

November 11*th*, 1886.

Present: Mr. E. J. White, Vice-President (in the chair), and 16 members and associates.

In pursuance of Law XLVII. the Antarctic Exploration Committee was reappointed to enable it to act during the recess.

The Vice-President notified that the Council had appointed a Printing Committee, consisting of Messrs. Ellery, Griffiths, and Rusden, to supervise the printing of papers and Transactions during the recess.

The Librarian reported that among 120 publications received was a portfolio containing reprints of the oldest existing maps of Australia, presented by the Government.

Dr. M'Gillivray presented two papers—(1) "Description of New, or Little Known, Polyzoa," Part XII.; and (2) "Catalogue of Marine Polyzoa of Victoria."

Mr. Lucas then read an abstract of Mr. Dennant's paper, entitled "Notes on Post Tertiary Strata in South-western Victoria," and pointed out the main characteristics of the two geological formations examined by Mr. Dennant. One of these—the "Banksivia" Deposits—was described for the first time, and a list of 141 species found therein was given, including 13 not met with before.

Discussion followed, in which Messrs. White, Griffiths, Rosales, Lucas, Tisdall, and Wild took part, particularly as to the origin of the sand dunes, attributed by Mr. Dennant to the action of wind, which was corroborated by Dr. Wild in an account of similar formations in Bermuda.

December 9th, 1886.

Present, the President, Professor W. C. Kernot, M.A. (in the chair), and 16 members and associates.

On the motion of Mr. Ellery and Mr. Blackett the auditors were re-elected—namely, Messrs. James E. Gilbert and Mr. Robert E. Joseph.

The President read the list of retiring office-bearers, and ten nominations were received for seats on the Council.

The President read a report of the preliminary meeting held in Sydney on the 10th November for founding an Australasian Association for the Advancement of Science in 1888.

Mr. Ellery moved that the Printing Committee be empowered to amend the rules, and print the next volume during the recess. This was approved.

The President reported the approval by the Council of the proposal made by Mr. Lucas at the last meeting to appoint a committee to initiate a marine survey of the fauna and flora of Port Phillip, and preserve a record of the results. He thought it furnished a good opportunity for the formation of Section C. of Natural History and Geology in pursuance of the fifty-third law of the Society.

Mr. Lucas was confident of the active co-operation of Dr. M'Gillivray and Mr. Bracebridge, of Geelong.

Mr. Ellery and Mr. Blackett strongly supported the proposal.

The President announced that the Council had decided that the progress report of the Antarctic Exploration Committee should be published in the forthcoming volume of the Society's Transactions. He read a letter received from Captain Gray, of Peterhead, and informed the meeting that Mr. Campbell had presented the Society with a number of Queensland Government reports, for which a vote of thanks was accorded to that gentleman.

Mr. Griffiths then read Professor F. M. Krause's paper "On the Tripolite Deposits of Lilicur."

Discussion ensued, in which Messrs. Ellery, Selby, and Griffiths took part.

Mr. Campbell then read his paper, entitled "On the Want of a Uniform System of Experimenting Upon Timber," and the subject was discussed by Mr. Skinner, Mr. Tisdall, the President, and Mr. Campbell, the proposals in the paper meeting with general approval.

Mr. Tisdall gave a description of the lake recently discovered at Mount Wellington, in Gippsland, and exhibited some geological specimens collected in its vicinity.

The President exhibited some beautiful sectional models of steam engines made by J. S. Schrœder, of Darmstadt, for the purpose of illustrating lectures, &c.

PROCEEDINGS OF SECTION A, 1886.

On the 31st March Professor Kernot read a paper on "Boiler Explosions."

On the 28th April Mr. John Booth, M.C.E., read the following paper on "The Testing of Large Dynamos."

On Some Expedients Employed in the Testing of Large Dynamos, with a Note on the Calibration of Am-Meters and Volt-Meters.

By the term "large dynamos" I here mean to refer to those which it would be inconvenient to test with their working load. No one, for instance, would care to bring some hundreds of incandescent lamps into the test-room every time a dynamo was to be tried.

The work done in any circuit is equal to the product of the electromotive force (E.M.F.) by the resistance, from which, in conjunction with Ohm's law, it follows that if the machine is kept at such a speed as to maintain the proper E.M.F. at its terminals, and the current be passed through any resistance equal to that of the working load, the effect, in as far as regards the dynamo, is the same.

The question that arises, then, is to find some suitable resistance, in heating which the machine can expend its energy. A length of wire is one of the first things that suggests itself, and, since resistance and not conductivity is desired, and a considerable quantity has to be employed, an inexpensive metal is naturally used—generally iron wire, and in the form of thick spirals—to economise space.

There are, however, serious drawbacks to this simple method. Unless the wire is very heavy, the heating, due to the passage of a large current, will be serious. On the other hand, if the wire is thick, it has also to be long, and thus becomes both cumbersome and expensive. Moreover, it has been found that the change of temperature in the hot wire, due to passing draughts of air, affects its resistance to an inconvenient degree, and entirely destroys any hope of accurate work.

These difficulties may be almost entirely obviated by placing the spiral in a stream of running water. This enables a much smaller wire to be used, and it is not so liable to variations of temperature; at any rate, they are not sudden. In this way I have put the full load on a 7000 Watt machine doing 300 amperes, and had all the resistance in a trough 4 feet long by 8 feet square.

Large electrolytic cells have also been used, with carbon or lead for the electrodes, but the change of resistance is rapid, and there is also the counter E.M.F. to be allowed for.

If pure water is used as the electrolyte, its resistance with electrodes of any convenient size is very high, too high indeed—unless the cell be made inconveniently large—for any E.M.F. that is not considerably over 100 volts. Two carbon rods, for instance, 6 in. x $\frac{1}{2}$ in. diameter, placed one inch apart in ordinary Yan Yean water, have, roughly, a resistance of 50,000 ω, which on a 50 volt machine would only represent a load equal to $\frac{1}{1000}$ of a 20 c.p. Swan lamp.

If sulphuric acid or a saline solution is used, its composition changes very rapidly, and the temperature rises so much that it is desirable to have a running stream, which either alters the strength of the solution, or necessitates a very large reservoir of the liquid.

Having then selected a form of resistance, the circuits may be arranged as in Fig. 1. There it will be seen that the current and E.M.F. are measured directly, and the work done is determined.

In the case of machines intended for lighting purposes it is often desirable to see the lamps actually alight; at any rate, it is often likely to satisfy an intending purchaser better than the readings on some delicate and mysterious instrument which he does not understand. In that case lamps may be introduced as in Fig. 2, if the machine is to burn them in simple parallel.

When the E.M.F. of the dynamo is much higher than that of a single lamp they may be arranged as in Fig. 3, where the effect of both the current and the E.M.F. may be seen in the different groups of lamps, and the E.M.F. may also be checked by a low reading volt-meter placed in parallel with the lamps.

With the circuit arranged as in Fig. 1 we have, in order to put any given load on a dynamo, to so adjust the resistance that we get the required current, while the E.M.F. is maintained at the desired voltage by modifying the speed of the engine. With a high tension dynamo, as depicted in Fig. 3, we have to adjust the resistance till the volt-meters V_1 and V_2 read the same, and then the load can be determined by the reading of the am-meter A and volt-meter V_3, or the E.M.F. may be obtained by taking the fall of potential due to one lamp, indicated by V_1 and V_2, and multiplying it by the number of lamps in series.

Note on the Calibration of Am-meters and Volt-Meters.—In tests such as those here mentioned it is very desirable to frequently calibrate our instruments. Fig. 4 illustrates a simple and effective method of doing this.

Consider the circuit represented by Fig. 4. Suppose the branch A.C.B. is of resistance r, and contains an E.M.F., e. Suppose the branch A.D.B. is of resistance R, and contains an E.M.F., E. The branch A.B. of resistancy.

Then the current in A B is $\frac{E\,r + e\,R}{r\,R + r\rho + R\rho}$, and when this is zero, then $E\,r = -\,e\,R$, or $E = \frac{R}{r}\,e$ numerically.

Let LL′ (Fig. 5) be a wire conveying an unknown current through the am-meter to be tested. We want to determine this current, and thereby the value of the indications on the am-meter.

Insert a known resistance, **P**, between the points ll' in LL, and connect up two resistance boxes, a galvanometer, and a battery of known E.M.F., as shown.

Adjust R and r till the galv. shows no current in A.B.

Then we have

$$E_{LL'} = \frac{R}{r}\,E_{bb'}$$

Where $E_{LL'}$ is the dif. of potential of the points l and $l' =$ **E** say, and E_{bb} is the known E.M.F. of the battery $= e$.

The current in ll' or LL′ is therefore $\frac{\mathbf{E}}{\mathbf{P}} = \frac{\frac{R}{r}e}{P} = \frac{R\,e}{r\,\mathbf{P}}$ or $\frac{e}{r\,P}\cdot R$

Or, for example, if we make $\mathbf{P} = 0{\cdot}1$, $e = 1$, and $r = 1000$. We have

$$\text{current in } \underset{l}{LL'}\ \frac{100 \times 1}{1000}\cdot R = \frac{R}{100}$$

NOTE.—Since R is assumed to be the resistance of the circuit A.$l.l'$.B., it must be great compared to **P**, and the connections. Similarly, r must be great compared to the battery and connections; and in order that $C_{ll'} = \frac{\Delta\,ll'}{P}$ may be true, **P** must be small compared with the total shunt resistance between l and l'. Otherwise, the total resistance of each branch must be ascertained. The material of which resistance P is made must be of such conductivity as not to be sensibly altered by the passage of the heavy current, or it must be measured while hot. It is obvious that the accuracy of this method depends only on the delicacy of the galvanometer and the accuracy with which the E.M.F. of the standard battery is known.

FIG. 1.

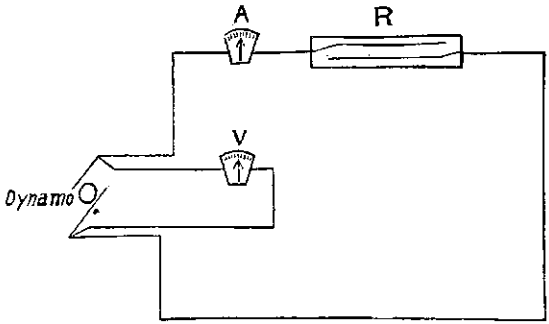


FIG. 2.

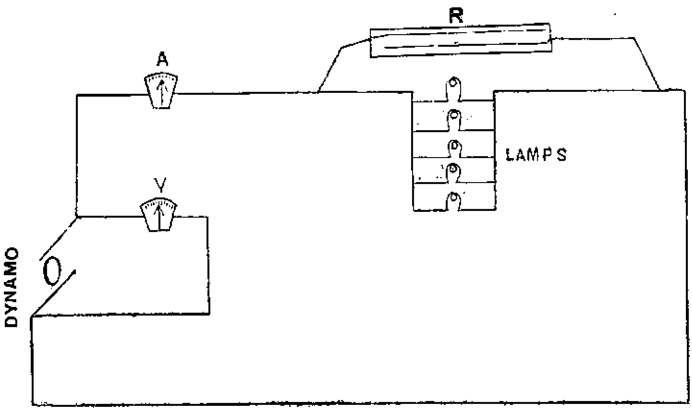


Fig. 3.

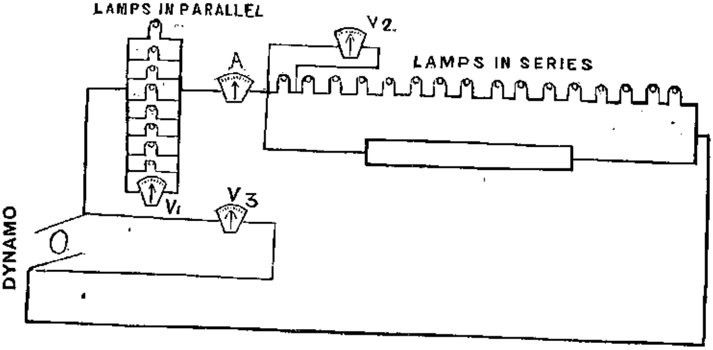


Fig. 4.

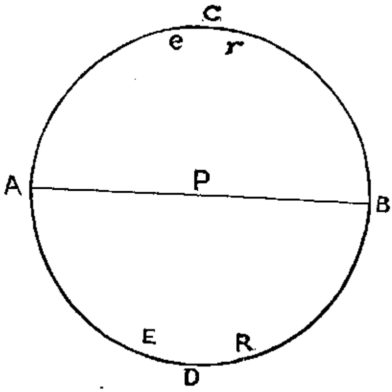
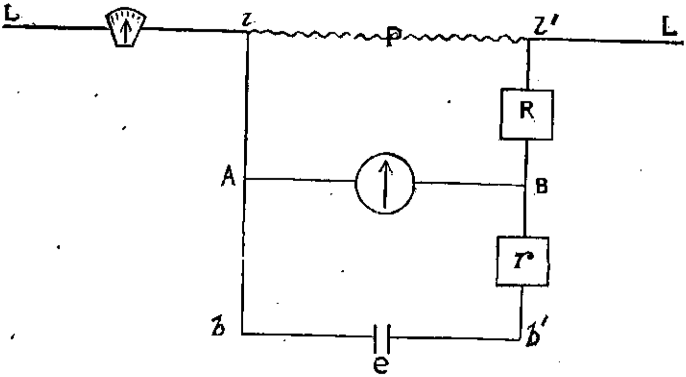


Fig. 5.



Mr. C. W. M'Lean also read a paper on "Modern Marine Indicator Diagrams."

On the 26th May Mr. G. R. B. Steane read a paper on "The Collimation of Levels," which was discussed on the 30th June.

On the 25th August Professor Kernot read some notes on Mr. J. A. L. Waddell's pamphlet on "Japan Railway Bridges," which was discussed.

On the 29th September Mr. C. W. M'Lean read a paper on "Safety Valves," a brief extract from which follows:—

"No safety-valve for steam boilers can be considered complete unless it fulfils the following conditions:—1. It must by its own action prevent the steam pressure from rising more than slightly above the working pressure to which it is loaded. 2. It must not waste more steam than is absolutely necessary; therefore it must close when the pressure falls again to the working load. 3. It must always be free to act efficiently without extraneous aid. 4. The parts must be so closed in that they cannot be tampered with or accidentally damaged. 5. For marine, locomotive, crane, and other boilers it must be unaffected by motion or vibration. Lever-weighted safety-valves gave place to dead-weighted valves regulated by the Board of Trade rules. These, on account of never opening more than 1-16th of an inch, in turn gave place to spring-weighted valves, now the most common for any but land boilers. The improved valves, by reason of their lips, which are made to throttle the steam after its exit from the boiler, and thus increase the area of the valve acted on, lift more freely. The accumulation of pressure rarely exceeds 10 per cent. when the fires are forced for 20 minutes." Among many novelties and improvements mentioned, the steam-loaded safety-valve invented by Mr. Alexander Wilson, of Melbourne, is described. This valve's action, in the writer's experience, meets the conditions of a perfect valve, set forth at the commencement of the paper, in a more perfect manner than any other known.

PROGRESS REPORT OF THE ANTARCTIC EXPLORATION COMMITTEE OF THE ROYAL SOCIETY OF VICTORIA AND OF THE ROYAL GEOGRAPHICAL SOCIETY OF AUSTRALASIA (VICTORIAN BRANCH).

THE Antarctic Exploration Committee presents below its first Progress Report to the members of the Royal Society of Victoria and of the Royal Geographical Society of Australasia.

Since the appointment of your Committee in June last, it has held eight meetings; five at the Town Hall, Melbourne—on the 10th June, 15th July, and the 10th and 30th November, 14th December, 1886; one on 21st January, 1887, at the Observatory; and on 28th January, 1887, and 1st February, at the Athenæum.

The first meeting was occupied with preliminaries, and in determining the course of action to be pursued. In consequence of resolutions passed at the second meeting, a memorandum of the desirable objects to be served by Antarctic research was printed and circulated. Copies were forwarded to the Premier and the leading papers, and to the Governments and scientific societies of neighbouring colonies. Others were sent to the secretary to the Antarctic Committee of the British Association for the Advancement of Science, and to other influential persons; and the Hon. the Premier, with whom your Committee had an interview on the 4th August, was good enough to telegraph to the Agent-General in London on the subject, and to express himself favourably to the enterprise generally. That telegram appears to have aroused immediate attention among persons in Europe interested in whaling, &c., for several communications were received by the earliest mail from London, Peterhead, Dundee, and Sandefjord in Norway, offering information, advice, personal service, and steam-whalers for sale or charter. From most of the Governments of the adjacent colonies and their scientific societies replies were received, expressing approval of the project, and a general inclination to contribute to its execution, the most cordial being that from Tasmania. From Adelaide was received an offer from Mr. Clement L. Wragge, formerly of the Ben Nevis Observatory in North Britain, to accompany gratuitously any scientific expedition as meteorologist. Another offer to command a whaling or pioneer voyage came from Captain Fairweather, of Dundee, who, though comparatively young, has had seventeen years' experience of ice navigation. A sympathetic letter was also received from Admiral Sir Erasmus Ommanney, the secretary to the Antarctic Committee of the British Association. In response to particular inquiries as to the meteorological conditions, the soil, and fauna and flora, in the Auckland, Campbell, and Macquarie Islands, the Honourable Mr. Seed, the Minister of Marine at Wellington, N.Z., and his officers, Mr. Chamberlain, at Dunedin, and Mr. Borrie, at Invercargill, have been most obliging in forwarding the fullest information procurable. It appears that a Government schooner is periodically sent from New Zealand to the Auckland Isles with supplies for possible castaways, and that attempts have been repeatedly made there to acclimatise goats, rabbits, fowls, and certain vegetables, most of which, however (except the rabbits), seem to have disappeared. Macquarie Island, though further south (54 deg. 44 min. S.), seems less barren, and some persons have resided upon it for several years. It was visited in November, 1880, by Professor J. H. Scott (of Otago University), whose interesting account of it contains much valuable information. This paper was received from Mr. Seed, together with an excellent report upon the Auckland Isles, written by Captain Greig, of the N.Z. Government schooner "Kekeno."

The letters from the gentlemen connected with the whaling interest in Europe confirm your Committee in the impression that the North Sea fisheries, which have long been failing, are now nearly profitless. In 1874 Captain Gray, of Peterhead, N.B., the reputed first living authority upon whaling, endeavoured to induce whale-ship owners to try the Antarctic Seas; but a temporary improvement in the Arctic catch diverted attention from the project, which has since remained in abeyance. A useful pamphlet which he published in 1874 with that object was forwarded through the Agent-General to your Committee by Mr. Tod, of Peterhead. From Messrs. David Bruce and Co., of Peterhead, also was received an offer of two steam-whalers — the "Esquimaux" and "Polynia" — for sale or charter. From Mr. Christensen, of Sandefjord, Norway, was received a similar offer of four steam-whalers for sale or hire, either for scientific purposes, or for a whaling expedition. Finally, a letter has just been received, through the kindness of Mr. Buchan, town surveyor of Collingwood, to whom it was addressed, from Captain Gray himself, of Peterhead, tendering three steam-whalers for the service, provided that satisfactory terms are offered to him. Captain Gray thinks that, after nearly forty years of North Sea whaling, he might himself be tempted to try Antarctic fishing for a year or two. He is quite confident of success, but justly says that it could be done far more profitably and economically from an Australian than a European port.

Admiral Ommanney is strongly of opinion that the mother country only can adequately equip and conduct a suitable scientific expedition, which *must* be naval. This expedition, consisting of two steamers equipped for a three years' cruise, would cost scarcely less than £200,000. The admiral cannot, however, move in the matter till after the next meeting of the British Association for the Advancement of Science, in September, 1887. But he regards with favour the proposal of an Australian pioneer expedition in a steam whaler, and thinks that the results might be extremely valuable. As an English expedition can scarcely be prepared to start before the end of 1888, or perhaps 1889, there should be plenty of time to carry the idea into effect. Captain Gray, or Sir A. Young, in the interim might be induced to undertake a whaling expedition to the South Polar Seas, and to carry hence two or three competent observers, by the offer of a bonus, to be augmented if his trip should *not* prove commercially profitable; and no doubt some good results might thus be achieved.

Mr. Christensen asks from £3500 to £6500 per steamer for a twelve months' voyage. The other gentlemen make no offer, but await one. The Agent-General, in a letter dated 26th November and just received, reports that he has had an interview with Sir Allen Young, from whom he expects in a few days particulars of an offer to lead a whaling expedition to the Antarctic Seas, if guaranteed £8000 or £10,000 to cover possible loss; the amount to be reduced by a certain sum for every whale caught. Whether he will carry scientific passengers at all, or proceed to high latitudes, and on what terms, remains to be seen when his offer arrives.

But there are other alternatives. Captain Gray suggests the formation here of a whaling company, and feels certain of its thorough success. Probably it would be most successful with his assistance on the spot, and with his ships. Still the scientific objects would be secondary, if not neglected, unless strictly provided for in the conditions of agreement.

Your Committee has, however, in view of the supposed greater expense of a purely scientific expedition, come to the conclusion to recommend the Government to advertise for tenders for a bonus, graduated at a certain sum for every degree of latitude above 70, to be given to any steam-whaler which will carry a few scientific passengers, and bring thence to Melbourne Antarctic products of a certain value, besides effecting a landing on the mainland near Mount Erebus.

Replies have been sent to the letters received, asking what subsidy would form a sufficient inducement to send whalers from Europe to carry hence a few observers, with an additional bonus should the voyage prove a commercial failure.

The appendix comprises the following documents:—

1. The prospective memorandum issued by the Committee.
2. The telegram of the Premier of Victoria to London.
3. His circular to neighbouring colonies.
4. Mr. Tod's letter from Peterhead, enclosing—
5. Captain Gray's pamphlet on "Antarctic Whaling."
6. Messrs. David Bruce and Co.'s letter, offering ships, &c.
7. Mr. Christensen's letter from Sandefjord, Norway, offering ships, &c.
8. Admiral Ommanney's letter from England.
9. Captain Fairweather's letter from Dundee, offering services.
10. Captain David Gray's letter from Peterhead.
11. The Agent-General's letter of 26th November, reporting interview with Sir Allen Young.
12. The Agent-General's letter of 10th December, enclosing Mr. Dessen's offer of ships.
13. Extract from private letter as to Sealing at Macquarie and Campbell Islands.
14. South Polar map, reproduced by Mr. Sprent from *Scottish Geographical Magazine.*

Many other letters have been received, and are available for reference, but your committee does not think it necessary to publish them, namely:—Mr. J. L. Sinclair's (Auckland), of 13th September and 25th October; Mr. F. L. Langdale's (Waikaiza, Fiji), of 26th September, 1886, and 26th November, 1886, offering service; Mr. Borrie's (Collector of Customs Invercargill), 15th October, 1886; Captain Greig's report on Auckland and Campbell Islands; Professor Scott's paper on Macquarie Island; Mr. Morton's (Secretary, Royal Society, Tasmania), 14th September, 1886; Mr. Clement L. Wragge's (Adelaide), of 6th September, 1886, offering services; the Secretaries of Royal Society of New South Wales and Linnæan Society of New South Wales, 6th August and 22nd July, 1886; Mr. J. S. Robertson's (Hobart), of 16th July, 1886; Mr. John Sangster's (London), 26th August and 16th September, 1886, to Agent-General, offering advice; Messrs. Thos. Bland and Sons (London), to Agent-General, offering new whaling gun; sundry letters from the Premier's and Agent-General's offices, &c.

Your Committee enumerated in its memorandum of 28th June some general advantages of Antarctic Exploration. But in reviewing the position it feels strongly the great advantages to be secured by losing no time in prosecuting researches in the South Polar Seas. The proximity of Australian ports gives these colonies a great facility for securing a share in the lucrative Antarctic whaling and sealing trade. To neglect these fisheries any longer would be not only to forego handsome commercial profits, but to abandon also our national maritime interest in these southern seas, and all the great advantages in relation to the Antarctic regions of our unique geographical position.

CRAWFORD PASCO, R.N., *President*, and F.R.G.S., M.R.G.S.A.

T. F. BRIDE, LL.D., F.R.G.S., M.R.G.S.A.

J. G. DUFFY, M.R.G.S.A.

R. L. J. ELLERY, F.R.S., M.R.S. of V.

G. S. GRIFFITHS, F.G.S., M.R.S. of V.

W. C. KERNOT, M.A., C.E., President of R.S. of V.

A. C. MACDONALD, F.R.G.S., M.R.G.S.A., and M.R.S. of V.

FERD. VON MUELLER, K.C.M.G., F.R.S., M.R.S. of V., and R.G.S.A.

H. K. RUSDEN, Hon. Sec., R.S. of V.

G. W. SELBY, Hon. Sec., R.S. of V.

J. J. WILD, PH.D., F.R.G.S., M.R.S. of V.

RECOMMENDATIONS FROM THE ANTARCTIC COMMITTEE APPOINTED BY THE ROYAL SOCIETY OF VICTORIA AND THE ROYAL GEOGRAPHICAL SOCIETY OF AUSTRALIA (VICTORIAN BRANCH), TO THE HONOURABLE THE PREMIER:—

1. The Antarctic Committee begs respectfully to recommend to the Honourable the Premier the propriety of stimulating Antarctic research by the offer of bonuses.

2. That a sum of £10,000 be placed upon the Estimates, to provide for the amount of the bonuses, and for the expenses of the equipment and of the staff.

3. The amount of the bonuses to be paid to the shipowners for the hereinafter mentioned services is to be decided by tender, and the same, together with the cost of equipment and the staff, not to exceed the sum of £10,000.

4. That the Government invite tenders from shipowners willing to perform the services required.

5. That the tenders be sent to the Treasury direct, or through the Agent-General, not later than the 1st June.

6. That tenderers must provide two fortified steam ships, each of not less than 175 tons register, 60 horse-power nominal, and A1 at Lloyd's, or of an equivalent class.

7. That tenderers must supply full descriptions of the ships and their equipments.

8. That the master and chief mate of both ships shall have held similar positions in Arctic steamships.

9. That the tenderer shall provide, free of charge, cabin accommodation in each ship for two gentlemen, who will sail as the scientific staff; also a separate cabin, of a size to be specified, as instrument room and office.

10. The scientific staff will have the status of cabin passengers, and be subordinate to the master, but the master must afford them every facility, that does not interfere with the work or safety of the ship, for noting natural phenomena.

11. The chartered ships will earn a special bonus (to come out of the £10,000 appropriated) upon their entering at the Custom House a cargo of 100 tons of oil, being the produce of fish caught south of 60 degs. S. The special bonus to be paid as follows, viz.:—To ships owned and registered in Australia, £1000; to ships owned and registered elsewhere, £800.

12. The services desired are as follows, viz.:—A flying survey of any coast-lines lying within the Antarctic circle, and not now laid down upon the Admiralty charts. The discovery of new waterways leading towards the South Pole, and of harbours suitable for wintering in. Opportunities to be afforded to the scientific staff to add to our knowledge of the meteorology, oceanography, terrestrial magnetism, natural history, and geology of the region. The discovery of commercial products.

13. The tenderer must specify the bonus he demands for passing 70 degs. S. with either one or two ships; also the bonus he demands for each degree attained beyond 70 degs. S. by one ship; also the bonus he demands for every occasion upon which he succeeds in establishing on the shore a temporary observing camp.

14. That the Government should pay for only one such station for each 120 miles of latitude or longitude, unless the master shall have established more at the written request of both members of the staff.

15. The staff to have the right to refuse to accept the site of any camp selected by the master, and such refusal shall be logged by the master, and read over to the staff in the presence of the mate and the surgeon; and the staff shall hand to the master their objections thereto in writing, and the same must be signed by both of them.

16. The tenderer will not receive any more bonus for two ships than for one after passing the 70th parallel. The committee would prefer that one of the ships should remain fishing in the neighbourhood of North Cape, Victoria Land, whilst the other pushed into higher latitudes. In case of accident to the latter, the former would serve as a depôt and relief for the shipwrecked crew to fall back upon.

17. Should the master of either ship despatch an exploring party from his vessel, the contractor will be entitled to a bonus for each sixty miles of latitude or longitude traversed by such party, but the tenderer must specify what sum he will require for each sixty miles so traversed.

18. That the ships should proceed direct to the bight situated on the meridian of 180 degs., with a view of one of them getting beyond Ross' furthest, and especially of observing the conditions of the volcanoes at the head of the bight.

19. The contractor will be liable to no penalty should he fail to reach to any latitude tendered for.

20. The contractor will have the right to employ his ships in whaling or sealing, and in loading guano or other cargo.

21. Should the masters be unable to get right or sperm whales to enable them to compete for the bonus offered under the 12th proviso, they will nevertheless be entitled to the bonus should they return with a cargo of any merchantable commodity obtained within the Antarctic circle, and having a value equivalent to that of 100 tons of whale oil.

22. Both ships must be in Port Phillip Bay and ready to start on the 15th of October.

23. That in case of any difficulty arising in England between the Agent-General and the contractor, it shall be referred to the British Antarctic Committee for decision.

APPENDICES.

No. 1.

A MEMORANDUM OF THE OBJECTS TO BE SERVED BY ANTARCTIC RESEARCH.

1. An Antarctic Exploration Committee having been appointed by the Royal Society of Victoria and the Geographical Society of Australasia, its members desire to place before the public a brief memorandum of the objects to be served by the enterprise.

2. Nearly fifty years have elapsed since the last expedition was despatched to the South Polar regions, and this Committee consider that the time has arrived when another might be sent out with advantage. Such a project was first mooted, some considerable time since, by our colleague, Baron von Mueller, in his inaugural address to the Geographical Society. The Antarctic is situated so near to us, and it forms so considerable a region that, if its exploration will serve any valuable purpose, the interest Australasia has in its accomplishment ought to be greater than that of any other community. Some of the learned societies of Great Britain and the Continent are now engaged in promoting such an enterprise. Under these circumstances it behoves us to consider what the objects of Antarctic research may be, so that, if the project be worthy of support, we may assist in the undertaking.

3. Geographical discovery has ever borne an extended Commerce as its fruit, while simultaneously promoting various utilitarian

sciences. Its objects naturally divide themselves into discoveries which may offer to mankind a direct return in the shape of new stores of merchantable products, and discoveries which simply add to our stock of knowledge.

4. The whale trade has been a lucrative one in the past, but the steady warfare so long maintained against these animals has now nearly exhausted all the old fishing grounds, so that last year the whole English whaling fleet returned almost empty. Now, there is reason to believe that an abundantly stocked fishing ground exists within ten days' sail of Australia, only awaiting the advent of steam whalers to yield rich returns. Captain Cook reported seeing numerous whales within the Antarctic Circle; and Ross says—"We saw a great many whales whenever we came near the pack edge, chiefly of a very large size."—(*Ross' Voyage*, Vol. I., p. 265). This was off North Cape, Victoria Land, in 69 degs. S., 167 degs. E., or in sight of Antarctic land. Accompanying these whales where many seals, some believed to be of the most valuable kind. He discovered on the same shores extensive guano deposits also—"sufficient to afford cargoes for whole fleets of ships for years to come."—(*Ross*, Vol. I., p. 189; *M'Cormick*, Vol. I., p. 152.) Were the new expedition to confirm the existence of an abundant supply of sperm whales, and fur seals, and of shores elastic with guano, branches of a decayed colonial trade might be galvanised into fresh activity. Australian whaling has hitherto been conducted in sailing ships, and these have confined themselves to fishing grounds lying well to the north of 50 degs. S. Seamen refuse to venture into higher latitudes, and will not willingly fish even within the zone of the westerly winds. To navigate the icy but calmer regions lying beyond the "Roaring Forties," steam whalers, are a necessity. It might assist explorers by providing them with a base depôt, if the Antarctic Islands were to be stocked with hardy animals and birds, as well as with cold-enduring plants and herbs, and even permanent settlements might eventually be promoted by such means.

5. It would indeed be strange if an unexplored region, 8,000,000 square miles in area—twice the size of Europe—and grouped around the axis of rotation and the magnetic pole, could fail to yield novel and valuable data to the investigator.

Our acquaintance with the geography of the region is excessively limited. We have charted a few discontinuous coast lines between 45 degs. and 180 degs. E. and between 45 degs. and 75 degs. W. Ross just viewed the coasts of Victoria Land; twice he approached its shores, discovering its huge volcanoes and its icy barrier. We do not yet know whether these scattered shores constitute parts of a continent or whether they are, like the coasts of Greenland, but portions of an archipelago, smothered under an over-load of frozen snow which conceals their insularity.

6. Further observations of the local sea currents with their temperatures are desirable, with a view of ascertaining the existence of open water or of passages leading towards the Pole.

7. Dr. Croll has calculated that the edge of the Polar ice cap must be squeezed off the land at the minimum rate of speed of a quarter of a mile per annum, and this estimate requires to be checked by actual measurement.

8. Many interesting geological problems present themselves for solution; amongst others the structure of the cones of the volcanic mountains, Erebus and Terror, may be modified superficially by the intercalation of layers of frozen snow between the strata composed of ejected matter.

Again their position at the end of a line of weak earthcrust, which, starting near Behring's Straits, passes through New Zealand, renders it a matter of importance that their recent condition should be known, as it might be such as would confirm or confute the existence of a seismic connection with the latter island, which is now speculatively inferred.

9. The discovery of fossils in any Antarctic formations would be an event of peculiar interest. The South Polar regions may have had secular climatic changes as great as those which have been experienced by the North Polar. If such have occurred—if South Polar lands now icebound were once as prolific of life as Disco and Spitzbergen have been—then, like Spitzbergen and Disco, they may still retain organic evidences of the fact in the shape of fossil-bearing beds, and to find these would be to discover the key to the past history of the southern hemisphere.

10. The climatology of this region requires further investigation. The permanent existence of extreme conditions over an area so immense, and situated so near to Australasia, must re-act powerfully upon our climate. The weather recorded in the highest southern latitudes yet attained was marked by calms, blue skies, clear atmosphere, and a limited range of temperature concurring in a degree which contrasts favourably with the climate of the Arctic, and which surprised Ross and his companions.

11. The position of the South Magnetic Pole ought to be again determined in order to ascertain whether any change of location has occurred since Ross' time.

12. It is desirable that pendulum observations should be taken at points situated around and as near as possible to the Pole in order to enable physicists to calculate the form of that part of the earth's figure.

13. The phenomena of auroras present a wide and important field for research; extended observations, such as Dr. Sophus Tromholt has recently made in the north, ought to be repeated in the southern hemisphere, but to be effective it is indispensable that they should be conducted in very high latitudes. Recently, some

advance has been made in our knowledge of their nature. They are found to change their character and the position of their maxima of intensity periodically—some phases occurring daily, others with the seasons; and in addition to these changes an eleven-year cycle of greatest intensity has been deduced.

14. Speaking generally, it is desirable that more precise knowledge respecting the physical conditions of the South Polar regions should be obtained, especially with reference to terrestrial magnetism and volcanic and seismic agencies, and still more particularly to the meteorological conditions of the several zones to the south of the 50th degree of latitude.

In concluding this memorandum the Committee desire to say that in the endeavour to achieve these objects the co-operation of the learned societies of the other colonies will be sought, and by its aid it is hoped that influential committees will be appointed in all the centres of population. Wherever possible lectures upon the subject should also be given. By such means as these, and with the assistance of the press, the project will be brought prominently before the public, and should the efforts put forth arouse a general and genuine interest in the undertaking, the several Parliaments of Australasia would be asked to contribute towards the necessary funds. Should the colonial Parliaments and the public respond favourably, this committee would be enabled to approach the English committee with a contribution which would justify it in asking that Australasia might be associated with the mother country in carrying through this great undertaking.

CRAWFORD PASCO, Chairman.

Melbourne, 28th June, 1886.

No. 2.

THE TELEGRAM OF THE PREMIER OF VICTORIA TO LONDON.

[COPY.]

REUTER'S TELEGRAM TO LONDON OF 19TH AUGUST, 1886.

Gillies received deputation learned societies urging Antarctic exploration, represented remunerative enterprise whaling, but asked Government encourage. Gillies replied willing give subsidy scientific discovery, ask other colonies join, meantime Agent-General to inquire if steam whalers disposed embark enterprise and what subsidy required.

No. 3.

Circular 1886/3108.

Premier's Office, Melbourne, 13th August, 1886.

Sir—A joint committee, appointed by the Royal Society of Victoria and the Geographical Society of Australasia, to consider the question of Antarctic exploration, having adopted a resolution to the effect that such an exploration is highly desirable, not only on scientific grounds, but also in the interest of commerce, a deputation from that body waited upon me on the 4th inst., with the view of endeavouring to secure the assistance and co-operation of this and of the other Australian Governments in making the necessary arrangements for the proposed enterprise.

The gentlemen constituting the deputation presented a printed memorandum (copy enclosed) setting forth the objects which an exploration expedition would, in their opinion, serve, and the representations which they made in support of their proposition appeared to me to be worthy of favourable consideration.

Under these circumstances, I undertook to bring the matter under the notice of the other Australian Governments, and I have much pleasure in now doing so, and in asking whether, in the interests of science, your Government would feel disposed to join in a subsidy, such as might lead to the despatch of an expedition to the Antarctic Seas.

By the last mail I requested the Agent-General for Victoria to make preliminary inquiries as to whether any of the proprietors of steam whalers would be disposed to embark in the enterprise, and what extent of Government aid would be expected.—I have the honour, &c.,

(Signed) D. Gillies, Premier.

No. 4.

MR. TOD'S LETTER TO THE AGENT-GENERAL.

Peterhead, 23rd August, 1886.

To the Consul-General for Melbourne, 8 Victoria Chambers, London, S.W.

Antarctic.

Dear Sir—Referring to the conversation I had with you on Thursday last, I now enclose the report of Captain David Gray upon the subject. As I stated to you, Captain Gray is the first authority in the kingdom in regard to the whale fishery, and the information contained in the pamphlet may therefore with confidence be relied upon.

I may remark that since the report in 1874 the market for oil and whalebone has considerably changed, and the quotations put in red ink may now be considered about the value. I may also add that the vessels of 800 tons register were considered the most suitable, on the basis of the fishing being prosecuted from Peterhead, but from the comparatively short distance from Melbourne, vessels of smaller tonnage would be quite suitable.—I am, yours respectfully,

(Signed) CHARLES TOD.

P.S.—I will forward you another copy of the report in a day or so.

No. 5.

REPORT ON NEW WHALING GROUNDS IN THE SOUTHERN SEAS.

By David and John Gray, Peterhead, N.B., with a Descriptive Appendix. Aberdeen: Printed by D. Chalmers and Co., Adelphi-court, Union-street, 1874.

We lately proposed to some of our friends to join us in considering a project for establishing a whale fishery in the Antarctic Seas, which had for some time engaged our attention. They desired before deciding to enter on an enterprise so novel and important, that we should submit to them the result of the investigations we had made in connection with the proposal, with such further information regarding it as we might deem it necessary to procure, and, in compliance with their desire, we now report the following observations:—

It is unnecessary that we should describe the regions to which our remarks are to apply further than saying that, unlike the Arctic area, where land predominates, the South Polar area is characterised by the predominance of sea, which has been navigated in various directions for considerable distances until further progress has been stopped by land or by a barrier of ice, both equally impenetrable. It is to the navigable part of this area alone, and especially to the icy region, which extends towards and within the Antarctic Circle, and forms the natural and favourite haunts of the right whale, that we desire to direct attention.

We have derived in the course of our inquiries on the subject valuable aid from the narratives of earlier explorers, but we are chiefly indebted to the account of the comparatively recent voyage of H.M. ships "Erebus" and "Terror" to the Antarctic Seas, under the command of the late Sir James Clark Ross, extending from the year 1839 to 1843. We have, besides, had the advantage of conferring personally with several of the officers of that expedition, who have willingly communicated to us much valuable information. We shall take care to note how far our observations are founded on the information acquired from these sources, and to refer to the authorities on which they are made. For the rest our own experience in connection with the fisheries in the Arctic Seas has led us to the conclusions at which we have arrived.

We think it is established beyond doubt that whales of a species similar to the right or Greenland whale, found in high northern latitudes, exist in great numbers in the Antarctic Seas, and that the establishment of a whale fishery within that area would be attended with successful and profitable results. These seas abound besides with all the other species of whale found in the northern Polar area —viz., the finner, hunchback, bottlenose, and grampus—excepting the narwhal, which seems to be unknown in the Southern regions. These, as is well known, are, in comparison with the right whale, of small value; and the only difference which appears to us to exist between what is termed the right whale of the southern and the Greenland whale of the northern latitudes is, that the head of the latter is higher on the crown than that of the former, causing the whalebone of the southern, as compared with that of the northern species, to be shorter, and consequently of somewhat less value. The produce of the southern variety, chiefly obtained by the capture of whales which had strayed from their natural haunts as far as the bays of New Zealand, has also commanded in the market a price somewhat inferior to that of Greenland produce, a fact which we attribute to defects in the mode of its manufacture.

It is not without encouragement to those who may embark in the proposed adventure that in the Antarctic regions the right whale exists in the greatest numbers near the margin of the ice. We infer from this that, as the Greenland fishery was long prosecuted with great profit in the comparatively open spaces in the northern seas until the whales, after years of persecution, left the open water and sought shelter amidst the floes, so the whales of the Antarctic seas frequent, in numbers comparatively unthinned, the margin of the South Polar ice, where they can still be reached with less difficulty than if they had been already driven to seek shelter in its recesses.

The inclemency of the weather of the Antarctic regions has, we are inclined to think, been somewhat exaggerated. It is true that the climate of the southern hemisphere, especially in high latitudes, is less genial than that of the northern, but a reference to the table which is appended, in which we compare the temperatures ascertained by us within the Arctic Circle in the months of June, July, and August, which correspond to those of December, January, and February in the southern hemisphere, shows that the difference is less marked than it has been supposed to be; and, with respect to the force of the wind and bad weather generally, our experience in the Arctic Seas has led us to encounter heavier gales than we find recorded in the narrative of Captain Ross' three years' voyage. As will also be seen from the comparative table appended, the force of the wind is, on an average, quite as great in the Arctic as in the Antarctic Regions during the months in question. It is, however, true that within the Antarctic Circle the ice rarely, if ever, thaws, and that sudden changes of wind, with alternations of gales and calms, and a heavy swell, occasioned by the fetch from the great Southern Ocean, continually prevailing with greater or less intensity, characterise the Antarctic Seas. This constant swell, which is frequently referred to by voyagers, would undoubtedly render the work of killing and "cutting in" a whale more difficult than if these operations had to be performed in the still water amongst the floes of Greenland. But it is not without advantage, for in the spring and summer months it breaks up the pack ice, and enables it to be easily penetrated, if necessary, for a considerable distance. The icebergs are certainly not more numerous in the South Polar Seas than in Davis' Straits; but they are found of such size, being often miles in length, that they serve, to some extent, as barriers against the effects of the swell, and afford good shelter to a ship under their lee.

It seems at first sight a proposition somewhat startling to affirm that it is practicable, and would probably be profitable, to despatch, on an ordinary whaling cruise, a vessel from the shores of Britain to prosecute the fishery in the Antarctic Seas, since it appears that the distance to be traversed is so vast, and that the length of the voyage would necessarily be so great. But we think such a conclusion, if arrived at, must, on consideration, be materially modified. We have been induced to select that region in the Antarctic area lying between the meridian of Greenwich and long. 90 degs. W., as the locality in which, in our opinion, the fishery we have projected might be prosecuted with the greatest advantage. It was explored by Captain Ross in his last voyage, and has been reported by him to be frequented by the right whale in great numbers. It is, besides, accessible from Britain by a direct route lying between the continents of Africa and America, not exceeding 7200 miles in length, or a two months' passage at an average speed of five knots per hour. We think that the month of December, corresponding to that of June in the northern hemisphere, which has generally been chosen for the commencement of the work of exploration in the Antarctic Seas, is too late, and that it might be prosecuted with advantage at least a month earlier. We would therefore recommend that, in the event of vessels being fitted out to prosecute the fishery in the South Polar Seas, they should leave this country in August, and reach the whaling ground by the end of October, which would give at least four months—viz., November, December, January, and February—ample time for completing their cargoes, and enable them to reach Britain again in May, thus leaving from three to four months for discharging and refitting before sailing on a new voyage in August. The ships might, for the purpose of refreshing the crews, call in the outward as well as the return voyage at the Falkland Islands, within ten days' sail of the fishing ground, where there are good harbours, easy of access, and where plenty of fresh provisions and good water are obtainable. Thus it will be seen that the length of time which would be occupied by such a voyage would not exceed that which is required for an ordinary whaling voyage from Britain to Davis Straits. The vessels which we think would be most suitable for the undertaking should be propelled by auxiliary engines of 120-horse power nominal.

We submit a statement which we have prepared, showing our estimates of the return which might be looked for by the employment of two such vessels as we have recommended, and what we think may be fairly calculated on as the result of a prosperous voyage, in which we have been careful to state fully the cost of the ships and the expenses of the voyage, and to estimate the value of the produce at moderate rates.

It may naturally be inquired why these fishing grounds, of which we have spoken in terms of such commendation as easy of access, and likely, on proper trial, to prove productive, have been so long, and still continue, comparatively unfruitful. On this point it is proper that we should report that in the year 1840 Mr. Enderby, of London, a merchant, whose name is honourably associated with Antarctic discovery, obtained from Government a grant of the Auckland Islands, situated to the southward of New Zealand, in order that they might serve for the location of an establishment for prosecuting the whale fishery, for which such a situation appears to be well adapted. From adverse circumstances, combined, we believe, with the fact that sufficient provision had not been made for the amount of capital requisite for the complete prosecution of the undertaking, it proved unsuccessful, and was abandoned after a single trial. We obtained an account of the proceedings of this enterprise, which seems to have led those engaged in it to conclude that the fishery had been fairly tried by them, and had proved a failure. But when it is considered that the vessel which was engaged in it left port on the 27th December, and returned on 22nd January following, after a lapse of only twenty-six days, it will be apparent that the effort had not been prosecuted with sufficient energy and perseverance to justify such a conclusion. The project has, however, been recently revived in a practical form in Otago, and the proximity of the shores of New Zealand to the fishing ground offers advantages which, it is hoped, may lead to its success. But there is still time, and, we believe, a field of ample extent, where properly equipped vessels, commanded by experienced masters, and manned by qualified men, may achieve the success which rarely fails to attend well-directed efforts of British enterprise.

(Signed) DAVID GRAY, JOHN GRAY.

Peterhead, N.B., January, 1874.

Appendix No. 1.

Extract from the Chapter on the Geographical Distribution of some of the Chief Plants and Animals in Keith Johnston's Physical Geography descriptive of the "Right Whales," page 203.

The right whales are the great representative mammals of the Polar Seas, and are sometimes nearly conterminous with the sperm whales which inhabit the warmer waters. The right whale—so called to distinguish it as the useful whale from the "finner," a large member of the species which has a dorsal fin, but little oil or whalebone—has its habitat in the icy regions, but may be found in the Atlantic as far south as a line joining Newfoundland to Spain, and in the Pacific, north of a curving line from the south of Japan to Vancouver Island. In the South Atlantic it advances from the Antarctic regions to beyond the latitude of Cape Colony and the La Plata; in the Indian Ocean to a line joining the Cape with the south coast of Australia; and in the Pacific it is found to the north of New Zealand in the west of the ocean.

No. 2.

Extract from an account by Captain Rhodes in March, 1799, *of Kerguelen Island in latitude* 49 *mins.* 20 *secs.* S., *and longitude* 69 *degs.* 24 *mins. E.*

When in command of the "Hillsborough," employed in killing sea-elephants, seals, and whales, after our arrival in the great south-west bay, I found the season had expired for killing sea-elephants and seals, but in the course of the same month we perceived the right or black whale to set into the different bays and harbours in great quantities. Our success was commensurate to my most sanguine expectations, and we remained here until October.

No. 3.

Extracts from the narrative of Captain Sir James Clark Ross, R.N., with reference to the presence of whales in the Antarctic Regions.

25th November, 1840.—Laurie Harbour, in the Auckland Islands, is well calculated for the location of an establishment for the prosecution of the whale fishery. Many black and sperm whales came into the harbour whilst we were there, and from such a situation the fishery might be pursued with very great advantage.

23rd December, 1840, lat. 59 degs. S., long. 171 E.—A few bottle-nosed whales were seen. A great many whales were seen during the afternoon of the 28th December, lat. 63 degs. S., long. 174 degs. 30. mins. E., at seven p.m. First iceberg seen before eight p.m.;

fifteen were counted from the deck. 29th December.—A great many whales were seen, chiefly of the common black kind, greatly resembling, but said to be distinct from, the Greenland whale. Sperm, as well as hunchback whales, were also observed. Of the common black species we might have killed any number we pleased. They appeared chiefly to be of unusually large size, and would yield a great quantity of oil, and were so tame that our ships, sailing close past, did not seem to disturb them. During the afternoon many marine invertebrata were taken, amongst them the Clio Borealis, upon which, doubtless, the whales were feeding, as it is well known that these creatures constitute the whale's food in the northern seas. 14th January, 1841, lat. 71 degs. 50 mins. S., long. 122 degs. 20 mins. E.—Great number of whales. Thirty were counted at one time, and during the whole day, wherever you turned your eyes, their blasts were to be seen. They were chiefly of large size, and the hunchback kind; only a few sperm whales were distinguished amongst them by their peculiar manner of blowing. Hitherto beyond the reach of their persecutors, they have here enjoyed a life of security, but will now no doubt be made to contribute to the wealth of our country in exact proportion to the energy and perseverance of our merchants.

15th January, lat. 71 degs. 56 mins. S., long. 171 degs. 51 mins. E.—Whales were seen in numbers, and they who may hereafter seek them will do well to keep near and under lee of extensive banks of ice to protect themselves from the heavy sea they will have to encounter. 25th January.—For several days past we had seen very few whales, which was the more remarkable on account of the very great numbers we met with sixty or seventy miles further north. The weather continued fine up to 31st January. Saw a great number of whales of small size, several of them marked with white patches. 16th February, lat. 76 degs. 32 mins. S., long. 166 degs. 12 mins. E.—A great quantity of whales of two different kinds were seen, the larger kind having an extremely long erect black fin, whilst that of the smaller was scarcely discernible. 1st March.—We saw a great many whales whenever we came near the pack edge, chiefly of a very large size, and I have no doubt that before long this place will be the frequent resort of our whaling ships. 18th December.—Amongst the ice, lat. 60 degs. 50 mins. S., long. 147 degs. W., a few whales of the finner kind were seen, and some small seals were basking on the ice. In the evening many whales were seen amongst the ice, and were so tame that the ships struck upon one in passing over it.

10th February, 1842, lat. 75 degs. 6 mins. S., long. 187 degs. 4 mins. W.—A few whales and a few finners were seen.

28th February, lat. 70 degs. 54 mins. S., long. 175 degs. 36 min. W.—Seals were comparatively few, but the small finback whale, as also the piebald kind, were numerous along the pack edge.

27th March, lat. 50 degs. 2 mins. S., long. 87 W.—A large company of bottle-nosed whales were seen.

29th December—Near Graham Land, we observed a very great number of the largest sized black whales, so tame that they allowed the ships sometimes almost to touch them before they would get out of the way, so that any number of ships might procure a cargo of oil in a short time. Thus, within ten days after leaving the Falkland Islands, we had discovered not only a new land but a valuable whale fishery, well worthy the attention of our enterprising merchants, less than 600 miles from one of our own possessions.

31st Decmber, lat. 64 degs. S., long. 55 degs. 28 mins. W.—Great numbers of the largest size black whales were lying upon the water in all directions; their enormous breadth quite astonished us. The colour of the sea was a dirty brown.

6th February, 1843, lat. 63 degs. 46 mins. S., long. 52 degs. 37 mins. W.—Seals were numerous; one killed measured 12 ft. 2in. in length, and weighed 1145 lbs.

No. 4. Notes of an interview with Mr. Davis, second master of H.M. "Terror," 1839-43.—Mr. Davis said that while in the Antarctic regions, a great number of whales were seen, but he could not say of what species they were. He had often heard Sir James Ross remark that a ship would have little difficulty in getting a full cargo. Sir James Ross knew whales well, having been thirteen voyages to the Arctic regions. He also remarked that the weather was very often overcast, but there was very little fog. He thought they were always too late in being out.

No 5. Notes of an interview with Dr. Hooker, F.R.S., Director of the Botanical Gardens of Kew, formerly surgeon of H.M.S. "Erebus," 1839-43.—Dr. Hooker was satisfied they did not see any right whales after they got among the ice at Victoria Land; those seen there were of a small species, not seen in the north. Mr. Abernethy, one of the petty officers, who knew about the northern whales, said they were different from anything he had seen there. South from the Falkland Islands, near Graham Land, great numbers of what Sir James Ross and others called the right whale were seen. We showed Dr. Hooker the drawing of a Greenland whale, and he said the whales seen near Graham Land were similar, but somewhat flatter on the crown. We compared Sir James Ross' journal and the account of his voyage with extracts from the journal kept by Dr. Hooker on board the "Erebus," which we examined, and they were both found generally to agree so far as they referred to the appearances of whales, although the species is not always mentioned by both. When, however, both mention the appearance or species of whales seen on any date the journals in that respect are found to agree.

No. 6. Notes of an interview with Mr. Beeman, boatswain of H.M. "Terror," 1839-43.—Mr. Beeman recollects hearing Mr.

Abernethy often remark about the finner whales and black whales. We showed him a drawing of a Greenland whale, and he said it was like whales he had seen in the Antarctic regions, except that the latter were somewhat flatter in the crown. The whales he chiefly noticed were short, broad, black whales. Whales were so common that they seldom took much notice of them. He had often seen the men amusing themselves by throwing pieces of holystone at them, and had seen herds of whales asleep on the surface. He had heard Sir James Ross say that it would be a splendid speculation to send ships here on a whaling voyage. Mr. Beeman considered that the expedition was always too late in being out by six weeks. They never experienced any bad weather until the end of the season. Snow was more troublesome than fogs, and he did not think there was any more difficulty in navigating the Antarctic than the Arctic seas.

No. 7.—Table showing the Highest Latitudes Reached within the South Polar Circle:—

Navigators.	Highest Latitude.	Longitude.	Date.
1. Bellinghausen ...	69° 30′ S	77° 0 W.	Jan., 1821
2. Weddell... ...	74° 15′ ,,	34° 17′ ,,	Feb., 1423
3. Ross	71° 30′ ,,	14° 51′ ,,	March, 1843
4. Bellinghausen ...	70° 0 ,,	93° 0 ,,	Jan., 1821
5. Cook	71° 15′ ,,	109° 0 ,,	Jan., 1874
6. Wilkes	70° 0 ,,	103° 0 ,,	March, 1839
7. Ross	78° 4′ ,,	173° 0 E.	Feb., 1841
8. Ross	78° 11′ ,,	161° 22′ W.	Feb., 1842

Note.—It will be observed that Nos. 1, 2, 3, and 4 refer to explorations in the immediate locality recommended for the prosecution of the fishery.

No. 8.—Comparative Table, showing the Mean Temperatures observed within the Arctic and Antarctic Circles respectively for the corresponding three months in each of the years undernoted, viz.:—

Within the Arctic Circle in the years 1871 and 1872.	Mean Temperature.	Within the Antarctic Circle in the years 1841, 1842 and 1843.	Mean Temperature.
June	32·2	December	40·15
July	35·9	January	30·13
August	38·5	February	27·17
Mean	34·9	Mean ...	32·48

No. 9.—COMPARATIVE TABLE, SHOWING THE MEAN AND GREATEST FORCE OF THE WINDS OBSERVED WITHIN THE ARCTIC AND ANTARCTIC CIRCLES RESPECTIVELY FOR THE CORRESPONDING THREE MONTHS IN EACH OF THE YEARS UNDERNOTED :—

Within the Arctic Circle in the years 1871, 1872 and 1873.	Mean Force.	Greatest Force.	Within the Antarctic Circle in the years 1841, 1842 and 1843.	Mean Force.	Greatest Force.
June	3·4	6	December ...	2·86	7
July	3·2	9	January ...	3·12	7·6
August ...	3·1	6	February ...	3·61	7
Mean ...	3·2	7	Mean ...	3·19	7·2

No. 10.—EXTRACT FROM THE "OTAGO TIMES" OF 2ND OCTOBER, 1873.

"The pioneer whaler of Otago, the 'Sarah Pile,' returned to the Bluff on the 30th ultimo, *after a four months' cruise.** She reports having experienced very heavy weather, owing to which she lost two whales she had killed. Nevertheless, she killed four others, and reports that plenty of them are to be met with. She leaves again immediately to continue her cruise. The 'Sarah Pile' is owned by a Southland resident, Mr. Printz, whose enterprise is deserving of reward. The Provincial Council of Otago has offered a bonus of £500 to the first whaler fitted out in Otago."

No. 11.—ESTIMATE OF THE COST OF TWO VESSELS FOR PROSECUTING THE WHALE FISHERY IN THE ANTARCTIC REGIONS, AND OF THE EXPENSES OF, AND THE RETURN WHICH WOULD BE YIELDED BY, A SUCCESSFUL VOYAGE :—

Cost of two vessels, each of 800 tons gross register, with auxiliary engines of 120 h.p. nominal, with full equipment		£54,400 0 0
Wages to crews for 9 months	£3000 0 0	
Provisions for 9 months	2160 0 0	
Insurance for 9 months at 5 %	2720 0 0	
Coals	1600 0 0	
Incidental expenses ...	1000 0 0	
		10,480 0 0
Total		£64,880 0 0

* The cruise of this vessel occupied the winter months of June, July August, and September, when inclement weather was to be looked for.

Estimated Return.

Value of 1000 tons of oil at £35				£35,000	0	0
Value of 1000 cwt. of whalebone at £320 per ton				16,000	0	0
				£51,000	0	0
Deduct.						
Oil money and expenses at £12 per ton	£12,000	0	0			
Bone-moving and preparing bone for market at £10 ton	500	0	0			
				12,500	0	0
Net estimated profit				£38,500	0	0
Substitute present rates and value of 1000 tons of oil at £22 per ton = ...	£22,000	0	0			
Value of 1000 cwt. of whalebone at £800 per ton =	40,000	0	0			
			=	£62,000	0	0
Deduct.						
Oil money and expenses at £12 per ton	£12,000	0	0			
Bone money and preparing bone for market at £10 ton	500	0	0			
			=	12,500	0	0
Net estimated profit				£49,500	0	0

No. 6.

MESSRS. DAVID BRUCE AND CO'S LETTER, OFFERING SHIPS, &c.

(Telegraphic Address, "Prudentia," London, David Bruce and Co., and at Dundee.)

3 Fenchurch Avenue, London, E.C., 27th August, 1886.

Robert Murray Smith, Esq., Agent-General for Victoria, Victoria Chambers, S.W.

Antarctic Exploration.

Sir—Following up the call we paid you last Friday with an offer of our whalers for the purposes of Antarctic Exploration, which we understand the colony is likely to embark upon, we beg herewith to hand you several particulars of our steamers "Esquimaux" and "Polynia," engaged, as you are aware, from year to year in the whale trade in the Greenland seas. We are sorry at not being able to wait upon you with plans, but in supplement to the particulars given on separate slips, beg to say that the "Esquimaux" got this year new compound engines, with new boiler, giving her fully 90-horse power, and that she cost, when new, something like £16,000, her engines then being only 70-horse power, and the new engines, &c., put into her this spring cost from £4500 to £5000.

Of course, we could make no offer or definite arrangement till we saw the vessels home from the Davis Straits fishing—say, end of September or early in October. However, it would be probably sufficient, in the meantime, that we place those two very suitable vessels before you, and any further information you may wish.

We may mention the steamers were specially built for the trade of Arctic fishing by Messrs. Stephen and Sons, of Dundee. They are very strong, doubled and fortified in every way, and as the oil preserves the timbers the hull of a whaler is supposed to last for some very indefinite time, age tending to make them all the more durable.—We are, sir, yours, &c., DAVID BRUCE AND CO.

Particulars of	"Esquimaux" and	"Polynia."
How rigged ...	Ship	Barque
Where built ...	Dundee, by A. Stephen & Sons ...	Dundee, by A. Stephen & Sons
When built ...	1865	1861
Material ...	Wood	Wood
Tons gross ...	593	472
Tons net ...	466	359
Length ...	157′ 3″	146′ 2″
Breadth ...	29′ 5″	29′
Depth ...	19′ 3″	18′ 1″
Nature of boilers	New boiler this year	
Nominal h.p. ...	90 h.p.	60 h.p.

No. 7.

MR. CHRISTENSEN'S LETTER FROM SANDEFJORD, NORWAY, OFFERING SHIPS, &c.

[COPY.]

TO THE FOREMAN OF THE ANTARCTIC COMMITTEE, MELBOURNE.

The Agent-General for Victoria in London was good enough to give me particulars of an anticipated expedition to the Antarctic Ocean, as well as handing me a memorandum from "The Antarctic Exploration Expedition Committee, Melbourne," respecting same.

Having perused the memorandum, as well as an article in the paper *Argus* of 6th August, I beg to make the few following remarks, at the same time naming the *probable* amounts which would be asked for whalers owned here in Sandefjord:—

1. The ships cannot carry any cargo out to Melbourne, as they would be fully loaded with coals, provisions, whaling boats, guns, harpoons, &c.

2. Whale or seal fishing cannot, in my opinion, be carried on simultaneously with a scientific expedition, for the following reasons:—

(*a*) Only half the number of men required for a whaling voyage would be wanted for a scientific expedition.

(*b*) The aim of the expedition seems to be to sail as far south as possible, to do which it must be prepared to stay the winter over, and therefore ought to be provisioned for two years, whereas a whaler is only provisioned for 4·6 months. Of still greater importance is it to save the bunker coals, hence these should not be wasted in chasing whales.

(*c*) In the Arctic Ocean *only* Greenland whales are caught among the ice, all the other species avoiding it. Probably the same occurs in the Antarctic Ocean; thus little scientific information would be gained there outside the ice.

(*d*) The time for seal fishing in the Arctic Ocean is in April, May, June, while an expedition to the North Pole would have the best chance to get farthest north in July, August, and September.

(*e*) The cabins on board a common whaler do not afford accommodation enough for scientific party *and* officers; thus a good part of the hold would have to be converted into cabins for the officers. This was the case with the "Vega" on her voyage round the world. She is here now.

3. To sail a whaler from Europe to Australia would be attended with no little risk and expense, as *the ships are iron fastened.*

Here are the following whalers and sealers for sale:—

"Jason," 497 tons gross, 60 h.p.; price here, £16,000.

"Hertha," about 265 tons gross, 35 h.p.; price here, £6500.

"Elida," 200 tons gross, 30 h.p.; price here, £5000.

"Fortuna," 165 tons gross, 20 h.p.; price here, £4000.

As Bonus.

For a scientific expedition that will occupy about one year, and on the condition that the charterers insure the vessel for its full value, while the owners find and pay the captain and crew, of whom the majority are experienced in Arctic voyages:—

For "Jason," £6500 for twelve months; afterwards, £200 per month.

For "Elida," £4500 for twelve months; afterwards, £150 per month.

For "Hertha," £5000 for twelve months; afterwards, £175 per month.

For "Fortuna," £3500 for twelve months; afterwards, £100 per month.

As Bonus.

For a sealing or whaling voyage, combined with a scientific expedition, but without any extra outlay on latter account:—

For "Jason," £5000; for "Elida," £3500; for "Hertha," £4000; for "Fortuna," £2500.

Further Remarks.

1. The bonus would be reduced if the vessel is bought after one voyage at the price stipulated.

2. The "Elida" was hired in 1883 by the Scientific Society of Utrecht (Holland) for the purpose of searching for the crew and Dutch scientific men per "Varna" (s.), which sunk in the Kara Sea that year.

Above are not positive offers. The ships belong to Sandefjord. They sail hence to the Arctic Ocean about 4th March, and return latest on 1st August. If the honourable committee wish to buy or hire one of these ships (they have first-class in the Norwegian Veritas) I shall be pleased to hear from them as soon as possible.

(Signed) Chr. Christensen.

Sandefjord (Norway), 30th September, 1886.

No. 8.

ADMIRAL OMMANNEY'S LETTER FROM ENGLAND.

[copy.]

Yarmouth, Isle of Wight, 6th October, 1886.

Sir—I have the honour to acknowledge the receipt of your communication, dated the 11th August, on the subject of Antarctic Exploration, informing me of the appointment of a committee at Melbourne to deal with the matter. I shall have great pleasure in laying the same before the Antarctic Committee of the British Association for the Advancement of Science.

I would, first, beg to acquaint you that, at the meeting of the British Association in Aberdeen last year, I took the initiative of pointing out the desirability of making further research in the Antarctic Polar region in a paper which I read on Antarctic Exploration, with a view of arousing public attention to that neglected portion of the globe. The result was the appointment of a small committee to report on the advantages to be derived from further research in the South Polar Seas. That committee, having promulgated their object, and gained many adherents to the cause, found it necessary to enlarge their number with influential men of science before preparing their report; consequently at the Birmingham meeting, held last month, the Antarctic Committee was augmented by several eminent scientific leaders, who are interested in the investigation of those branches of science which call for research in the South Polar region. I enclose a copy of the report and an abstract of my paper.

Having made this explanation, it is necessary to remind you that our report cannot be presented to the council of the British Association until the next annual general meeting, to be held at Manchester next September. In the meantime we will endeavour to secure the influence of the Royal Geographical and other scientific societies in promotion of our object. You can readily understand the great importance attached to the preparation of an appeal to Government, asking for a grant to provide for an expedition of such magnitude and such a perilous nature. It requires a strong case to be produced, showing the necessity of such a serious undertaking on scientific grounds. It seems to me to be advisable to follow the precedent adopted which led to the equipment of Sir James Ross' renowned expedition, which was obtained through the intercession made by the great *savans* of that time.

As an experienced Arctic voyager, I am pleased to observe that the views of your committee are in accord with mine, "that the exploring expedition must be entirely naval." The Admiralty organisation and naval discipline are indispensable for such an important national enterprise.

Much interest will be manifested in the pioneer voyage of the steam whaling ship that you allude to towards the Antarctic Sea, as her measure of success will influence future operations.

The leading scientific men in London will reassemble in November. I shall then bring your communication under the consideration of my committee. I suggest for your consideration the desirability of communicating to the Admiralty expression of the strong feeling manifested in the Australian colonies for Antarctic research. As regards the important question as to the precise share which the colonies might provide to carry out the expedition, I think this is a matter which cannot be dealt with before we are prepared with some plan of our proceedings and the number of vessels to be employed. It is most gratifying to find that such a noble spirit of enterprise exists in the Australian colonies. I would also advise you to make an urgent appeal to the Royal Geographical Society for their strenuous support in advocating this expedition.

In conclusion, I beg to assure your committee that I shall be proud to be of service in promoting our common interests towards bringing our objects to a successful issue.—I have the honour to be, sir, with the greatest respect, your obedient servant,

(Signed) ERASMUS OMMANNEY.

The Chairman of the Australian Antarctic Committee.

ENCLOSURES.

Antarctic Research, by Admiral Sir Erasmus Ommanney, C.B., F.R.S., F.R.G.S.

Aberdeen, September, 1885.

The object of this paper was to draw attention to the neglect of the Antarctic Region as a field for exploration. The author gave a summary of the work which has already been done by Cook, Bellinghausen, Weddell, Biscoe, Balleny, Wilkes, D'Urville, James Ross, and Nares (in the "Challenger"), and referred to a paper by Dr. Newmayer on the subject, reproduced in *Nature*, Vol. VII. The author concluded as follows :—I have thus laid before you but a very imperfect description of these voyages ; to give the details of the scientific results would occupy a separate paper. But I have endeavoured to demonstrate how large a field remains open for discovery. I think, from all we now know, we may infer that the South Pole is capped by an eternal glacier, and from the nature of the soundings obtained by Ross, it would appear that the great ice wall along which the ships navigated was the termination of the glacier—the source from which the inexhaustible supply of icebergs and ice islands are launched into the Southern Ocean, many of which drift to the low latitude of 42 degrees. The fact of finding volcanoes of equal proportions to Etna or Mount Blanc creates a zest for further research regarding that awful region on which neither man nor quadruped ever existed. No man has ever wintered in the Antarctic zone. The great desideratum now before us requires that an expedition should pass a winter there, in order to compare the conditions and phenomena with our Arctic knowledge. The observations and data to be collected there throughout one year could not fail to produce matter of the deepest importance to all branches of science. I believe that such an achievement can be accomplished in these days with ships properly designed and fitted with the means of steam propulsion ; nor is it chimerical to conceive a sledge party travelling over the glacier of Victoria Land towards the South Pole after the example of Nordenskjold in Greenland. Another interesting matter requires investigation, from the fact that all the thermometers supplied for deep-sea temperatures to Ross were faulty in construction, as they were then not adapted to register accurately beneath the weighty oceanic pressure. Moreover, another magnetic survey is most desirable, in order to determine what secular change has been made in the elements of terrestrial magnetism after an interval of forty years and more, when taken by Ross. In fact, there exists a wide field open for investigation in the unknown South Polar Sea. This paper will, I trust, be the prelude for others to follow in arousing geographers and this powerful association in promoting further research by despatching another South Polar expedition, having for its object to secure a wintering station. No other nation is so capable of providing and carrying it out. Even in the Australian colonies there exists the spirit and the means for such a noble enterprise, and he also directs the public attention to the fact that the only scientific information yet procured in the South Polar region within the Antarctic Circle is limited to the observations collected by the *only* expedition ever despatched from this nation expressly for scientific research.

REPORT OF THE COMMITTEE, CONSISTING OF SIR JOSEPH D. HOOKER, SIR GEORGE NARES, MR. JOHN MURRAY, GENERAL J. T. WALKER, ADMIRAL SIR LEOPOLD M'CLINTOCK, DR. W. B. CARPENTER, MR. CLEMENTS MARKHAM, AND ADMIRAL OMMANNEY (SECRETARY), APPOINTED FOR THE PURPOSE OF DRAWING ATTENTION TO THE DESIRABILITY OF FURTHER RESEARCH IN THE ANTARCTIC REGIONS.

Your committee, after having given full consideration to the great importance of effecting a further exploration of the Antarctic Polar Sea, desire, in the first place, to express their opinion that it would be most essential before approaching H. M. Government with the view of urging the expediency of equipping such a naval expedition as would be required for the carrying of an exploration of such magnitude, interest, and importance, that the requirements for its success and a plan of operations should be most carefully considered, and the results embodied in a written form for the approval of the Council of the Association, and for the information of the Government.

Furthermore, in order to obtain the co-operation which the matter requires from eminent men in science, your committee feel it necessary for their body being enlarged by the addition of influential members of the association, and of other bodies representing the various branches of science interested in the investigation of this comparatively unknown region, and especially of the Royal Geographical Society. Your committee have to point out that our knowledge of the South Polar region is chiefly confined to the grand discoveries effected by that celebrated expedition under the command of Captain Sir J. C. Ross, conducted between the years 1839-43 with sailing ships. Since that period the facilities for effecting a more complete research have been greatly augmented by the application of steam propulsion to vessels better adapted for ice navigation. This has been proved by continuous experience in the Arctic during half a century. For the above reasons your committee deem it desirable to defer making their report, with a view to giving more definition to the objects sought to be obtained and to the best means of obtaining them, as also to expand this committee, in order to elicit to the fullest extent the opinions, and to secure support from those conversant with the various branches of science which are to be investigated during an exploration which, from its very important and serious nature, eminently merits the favourable consideration of this great and enterprising maritime nation.

No 9.

CAPTAIN FAIRWEATHER'S LETTER FROM DUNDEE, OFFERING SERVICES.

Dundee, 28th September, 1886.

The Right Honourable the Governor of Victoria.

Honourable Sir—There is a rumour current here to the effect that an Antarctic Expedition and Whaling Enterprise is likely to be undertaken on behalf of the Victorian Government, and I venture to address you these in reference. I have been intimately connected with the North Sea whaling and sealing trade for upwards of seventeen years, eight of which have acted as master, and for the past five years I have had (and still have) command of one of the largest and finest steamers hailing from this port of Dundee. I would venture to ask, and would esteem it a favour, if you would inform me as to the authenticity of this flying report; and if your colony is really entertaining an undertaking of this sort, I would gladly avail myself of an opportunity of being connected with an expedition to the southern latitudes to look for the black or right whale. I am of opinion that our trade here is fast dying out on account of the continued catching and decadence of the whale in our northern waters. I have youth on my side, being only thirty-three years of age, and I would like to alter my cruise to the Antarctic Seas, as I feel convinced the whale must be numerous there, and consequently a succession of good cargoes would in all probability be obtainable. This is my chief reason for venturing to address you, and a second reason is that my father is buried in Australia, and I have a strong desire to see the spot where he lies. If the proposed expedition is to be purely scientific, the only capacity in which I could act would be with reference to my extensive experience with and knowledge of ice navigation. I hold a master's certificate of competency, and can produce the highest testimonials; on the other hand, if it is with a view to whaling, I would not leave here unless I was to get command of a steamer.

I will be in Dundee until about 1st February next, and a reply from you will be esteemed a favour by yours most respectfully,

(Signed) James Fairweather.

P.S.—Address enclosed.—J.F.

No. 10.

CAPTAIN D. GRAY'S LETTER FROM PETERHEAD.

The Links, Peterhead, 6th October, 1886.

W. R. Buchan, Esq., Council Chambers, Collingwood.

Dear Sir—Your letter of 9th August just received. I had seen in the newspapers that the Australian Government intended sending out an expedition to the Antarctic. At one time I thought of trying that fishery myself, and inquired very minutely into the matter, which I put into the shape of a small pamphlet, and had it printed, a copy of which I now send you for the information of those interested. The only difference since then is the price of the produce, and as the vessels were intended to sail from this country, they are consequently of a much larger size than I think necessary for ships sailing from Australia. The most suitable size for vessels intended for ice navigation with steam power is from 400 to 500 tons, with engines of 80-horse power nominal; they cost far less money, are easier handled, and can be sailed much cheaper than larger vessels. I may here mention that the reason why I never undertook the Antarctic voyage was, since the date of the pamphlet we have been doing so well in the Arctic until now that we had no reason to change fishing ground.

I do not approve of steam for whaling purposes, and I am confirmed in this opinion, after many years experience both in sailing vessels and in steamers. I know it has been the ruin of our northern fisheries. Steam is too apt to be used at the wrong time, and unless judiciously used in emergencies and in making passages only, it is certain to do great damage to the whale-fishing in a few years. The whales may not at first notice the noise of the engines, but they will very soon learn what it means, and will retreat through the ice, where it will be impossible to follow them. This is just what has taken place in the northern fisheries. I commanded a sailing vessel for eighteen years and a steamer for nineteen, and have found that I caught as many whales with the sailing vessel as I did with the steamers. Of course it is quite different if exploration is meant. Then the steamer is far better.

I do not like the idea expressed in your letter of intending to combine exploration with fishing, collecting guano, and other commercial products. I think if you do so you are sure to fail. Your commander's mind will be too much divided, and will be apt to leave one thing and go after another, especially if things are not getting on so well as he would like. I know this plan has never succeeded hitherto, and it is not likely to succeed in your case. Send your ships out to explore if you like, but let it be exploration only. And if you decide on a whaling voyage, confine your master's attention to that only, and I have little doubt you will succeed beyond your expectations. We have three vessels here, viz.:—

1. The "Erik," built in Dundee in 1865; 412 tons net, 533 gross; engines, 80 h.p. nominal. She got new steel boiler and new decks in 1884. She steams well, and is handy under canvas. I think her rather large. 2. The "Hope," built in Aberdeen in 1873; 307 tons net and 452 gross; engines, 80 h.p. nominal. Steams and sails well. We think her as good as new. 3. The "Eclipse," built in Aberdeen in 1867; 296 tons net, and 436 gross; got new engines of 80 h.p., and new boiler in 1877. She steams well, sails well, and is remarkably handy under canvas. She has been kept in first-rate order, and we think her as good as new. I do not know if any of them would be sent out on hire. It would depend on the terms. They might be sold if a suitable price was offered. So far as regards myself I am too old now to undertake such a distant expedition. I must leave that to younger men. However, should the Agent-General for the colony ask for my advice and assistance in promoting the expedition I will be very pleased to do so.

In the enclosed pamphlet I have altered the price of produce to suit present quotations. With smaller ships and a shorter voyage the expenses would be much less than I have stated them. Your best plan would be to get up a company and equip two or three vessels, taking your chance. It will be sure to pay. There are plenty of whales there, and it may turn out a more profitable fishing than ever the Arctic did. The Americans sold last year £180,000 worth of bone, taken in Behring Straits. Why should you not try and do so likewise? Besides, it would be a splendid school for your sailors, not to be equalled in any other trade, who may in the dim and distant future do their country valuable service in its sorest need.

I think I have about answered all that your letter required me to do, and if anything more is wanted I will be most willing to answer any questions that may be put do me, either in letter or in conference. Upon consideration I might entertain the idea of coming out with two of our ships, and working the fishery for a year or two if suitable terms were offered.—Yours, truly,

(Signed) David Gray.

"Enclosure." The Eclipse Seal and Whale Fishing Company, Peterhead.

Balance-sheet for Greenland Voyage, 1884.

	£	s.	d.		£	s.	d.
Paid out for wages	£900	13	1	Receipt for oil	£1990	0	0
Provisions ...	717	18	8	,, bone	4783	15	3
Coals and machinery	231	8	0	,, skins	1852	2	4
General charges ...	854	9	9				
	£2704	9	6				
Profit and Loss for Profit	5921	14	2				
	£8626	3	8		£8626	3	8

The foregoing balance-sheet shows the expenses incurred for a voyage of 5½ months' duration, with 55 men, and a catch of 205 tons of oil.

No. 11.

THE AGENT-GENERAL'S LETTER OF 26TH NOVEMBER, REPORTING INTERVIEWS WITH SIR ALLEN YOUNG.

[copy.]

4304. Antarctic Expedition.

Victoria Office, 8 Victoria Chambers, Westminster, S.W.
26th November, 1886.

Sir—In continuation of my letter of the 12th inst., No. 4071, I have the honour to report that there appears to exist considerable and growing interest in the above subject in England, and I have every reason to hope that the movement commenced in Melbourne will be warmly supported here. In addition to the information I have already conveyed to you, I have now to report an interesting interview which I had with Sir Allen Young, of Arctic fame. This gentleman called upon me last Friday, and intimated an earnest desire to forward the experiment of testing the Antarctic Ocean for whales. He said his own views were largely shared in by others engaged in whale fishery. The comparative failure last year in this trade, joined to the very high price now obtainable for whalebone (the oil is of quite secondary importance), which he stated had reached £2000 per ton, was directing attention to the Antarctic Ocean as a possible alternative. Very little is known about it, and Sir Allen had failed to obtain any useful information from the few survivors of Ross's expedition. Ross himself reported that he saw thousands of whales in those waters, but he was unable to ascertain if these were the whales of commerce. I am in hopes of receiving from Sir A. Young a practical proposal in a few days, which I will then forward to you. In the meantime I may state what is required as a guarantee against ruinous loss in the event of the ship returning clean. If, say, £10,000, or even £8000, were guaranteed by the Australian colonies, I think Sir A. Young would consent to go as captain himself. He was quite willing that the sum should be reduced if the voyage proved successful, say, *pro rata*, according to the number of whales secured.

This is certainly the most feasible proposal I have yet received, and appears to me the best mode of opening up that part of the world to scientific exploration. I see by the file of papers that the interest in the matter continues in Melbourne, and when the possibilities of the future are considered it would seem only reasonably politic to do something at once to secure a possibly lucrative trade to Victoria.—I have the honour, &c.,

(Signed) Graham Berry.

No. 12.

THE AGENT-GENERAL'S LETTER OF 10th DECEMBER, ENCLOSING MR. DESSEN'S OFFER.

Victoria Office, 8 Victoria Chambers, Westminster, S.W.,
10th December.

4522. [copy.]

Sir—In continuation of previous correspondence on the subject of the proposed Antarctic expedition, I have the honour to enclose for your information copy of a letter which I have received from Mr. H. F. Dessen, of this city, stating that he is in a position to make offers of ships suitable for that object. In replying to Mr. Dessen, I have suggested that he should submit alternative offers in accordance with the terms of his letter, and upon his furnishing me with these, I will forward them for your consideration.—I have the honour, &c., (Signed) Graham Berry.

"Enclosure." [copy].

3 Great Percy-street, W.C., London, 8th Dec., 1886.

Sir—Referring to the proposal set on foot in Melbourne to send an expedition to the Antarctic regions, I beg to inform you that I am in a position to lay before you offers of ships built for, and engaged in, the Arctic trade, and exactly suitable for such an expedition as the one proposed. They are built of wood, green heart planked, having steam power, and fitted with all the latest improvements—results which have been arrived at through long and constant trading and navigation in Arctic waters by the owners in Norway. The offer of a ship could include a complete outfit for sealing or whaling, and, what is probably the more important feature—viz., a crew of able and steady men experienced in the trade. If more convenient, an offer could be made of a ship at per month, and my friends would deliver her in Melbourne.—Your obedient servant, (Signed) H. F. Dessen.

No. 13.

EXTRACT FROM PRIVATE LETTER AS TO SEALING AND WHALING AT MACQUARIE ISLAND.

"If judiciously ordered and conducted by the owners or management of the vessel or vessels, one result of the expedition may be safely predicted—namely, a rich harvest in seal products—for this trip, and the opening of a wide field in that line to mercantile enterprise. With regard to whales, I am sceptical as to their existence in any great numbers in these regions, but seals and walrus are undoubtedly very abundant, and south of the Aucklands have scarcely been disturbed for the last fifty years. The Enderbys never did much in the sealing; but in 1828-30 it was vigorously carried on by the Underwoods, of Aberdeen, who had upwards of a 150 men stationed at the different islands, killing, &c., while a large schooner was employed picking up and conveying the produce to the main depôt, at Campbell's Island, where large ships loaded—oil to the home markets, skins for China, which at that time was the best, indeed almost the only market for the skins of the hair seal. Very few fur seal have been met with in the southern regions. Financial troubles overtook the Underwoods, chiefly by reason of home enterprises failing, but climaxed at the critical time by the loss of a fine, uninsured 1000-ton ship at Macquarie Island, where she had gone to take in the last few tons of her loading rather than wait for the tender. A gale coming suddenly from the eastwards, she failed to work out of the roadstead. So ended sealing in these parts to any extent worth mentioning."

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Grut, Percy de Jersey, Esq., E. S. & A. C. Bank, Elizabeth-street

Heffernan, E. B., Esq., M.D., Brunswick-street, Fitzroy
Henderson, A. M., Esq., C.E., Elizabeth-street South
Henry, Louis, Esq., M.D., Sydney-road, Brunswick
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