NATURE STUDY RAMBLES

ROUND

ST. ANDREWS

BY

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WITH ILLUSTRATIONS

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MCMX

To the Memory of

J. W.

IN TOKEN OF LIFELONG INDEBTEDNESS

AND OF FILIAL ESTEEM

PREFACE.

It has been my good fortune to have the opportunity of studying the Natural History of the district round my native city under conditions which could not but be conducive to the awakening of enthusiasm. To this has to be added the privilege I have very often enjoyed, of acting as an instructor of students and teachers in the course of explorations of this region. The principle animating those excursions has been the study of Nature rather than the pursuit of Science,—the acquisition of the explorer's comprehensive outlook rather than the specialist's concentration. I am not ignorant of the pleasure which indoor studies can afford, and the intense satisfaction which follows discovery as the reward of research in the laboratory; but for the great mass of those who wish to enjoy the refreshment and stimulus that come of intimate association with Nature, the excursion into the open is by far the most direct way to reach so desirable an object.

In the absence of someone acquainted with the district to be explored, time may be lost and interest dulled by failure to find what one reasonably expects to see. To moderate the effects of discomfiture, it is well to seek written guidance if nothing better exists. The freshness of the quest is, of course, lost if we merely follow in the footprints of others; but we may nevertheless go forth in the hope that those who have anticipated us have missed something which it may be our good luck to call attention to. We may be able to point to a word in the scroll of Nature which is written with a capital letter, not a small letter, as hitherto supposed; we may even decipher a cryptogram which will give the key to a passage or a page never before intelligible. It is consoling, if not encouraging, to remember that most naturalists have to acknowledge that although they had familiarised themselves with the outstanding characters of extensive areas, they had failed to notice points of extreme interest close to their own doors.

The following chapters have no pretensions to exhaustiveness. They would frustrate their own purpose if they did more than point the way. They are largely based on a course of lectures I had the great pleasure of giving in the University of St. Andrews, in the winter of 1908, supplemented by observations made in preparation for a series of excursions in connection with the Summer School held in 1909 under the auspices of the St. Andrews Provincial Committee for the Training of Teachers.

The botanical part has received most elaboration, because I have found that field botany is the subject which appeals most strongly to the majority of teachers of Nature Study, if not also to those who pursue open-air studies simply as a recreation. In this connection reference may be made to the present efforts of systematists to bring about uniformity in the nomenclature of our native plants. The resulting revision may satisfy the claims of justice with respect to priority, but it has certainly done much to desecrate old associations. Names that have been on the tongues of generations of field naturalists cannot be relinquished without a pang. If I have not named the Sea Pink *Statice Armeria*, it is because of the considerations suggested.

To my friend, Mr. John Lindsay, I have to tender grateful thanks for expert advice in respect of the arrangement of the work in all its stages, and for valuable suggestions, both literary and scientific, in its passage through the press. The thoughtful criticisms of my former colleague, Mr. William Bayne, and the assiduous practical help of my assistant, Mr. William Sanderson, have also been greatly to my advantage.

The photographic illustrations in the Plates are from my own negatives, the only exception being Fig. 11 of Plate VIII., for which I am indebted to Mr. William Balsillie. The Frontispiece is inserted by courtesy of Messrs. W. C. Henderson & Son.

With regard to the long-delayed recognition of Nature Study in the School curriculum, it may be recalled that an example worthy of being followed was set many years ago by the late Dr. W. O. Lonie, of the Madras College, St. Andrews. I cordially acknowledge my obligation to that able and sympathetic mentor, not only for introduction to the fascinating treatises by Dr. David

Page, and for an early practical acquaintance with the salient features of the Geology of the district round the city, but also for the inculcation of those personal attributes on which success as a teacher in so large a measure depends,—whole-hearted devotedness to one's subject and the free exercise of individuality.

JOHN H. WILSON.

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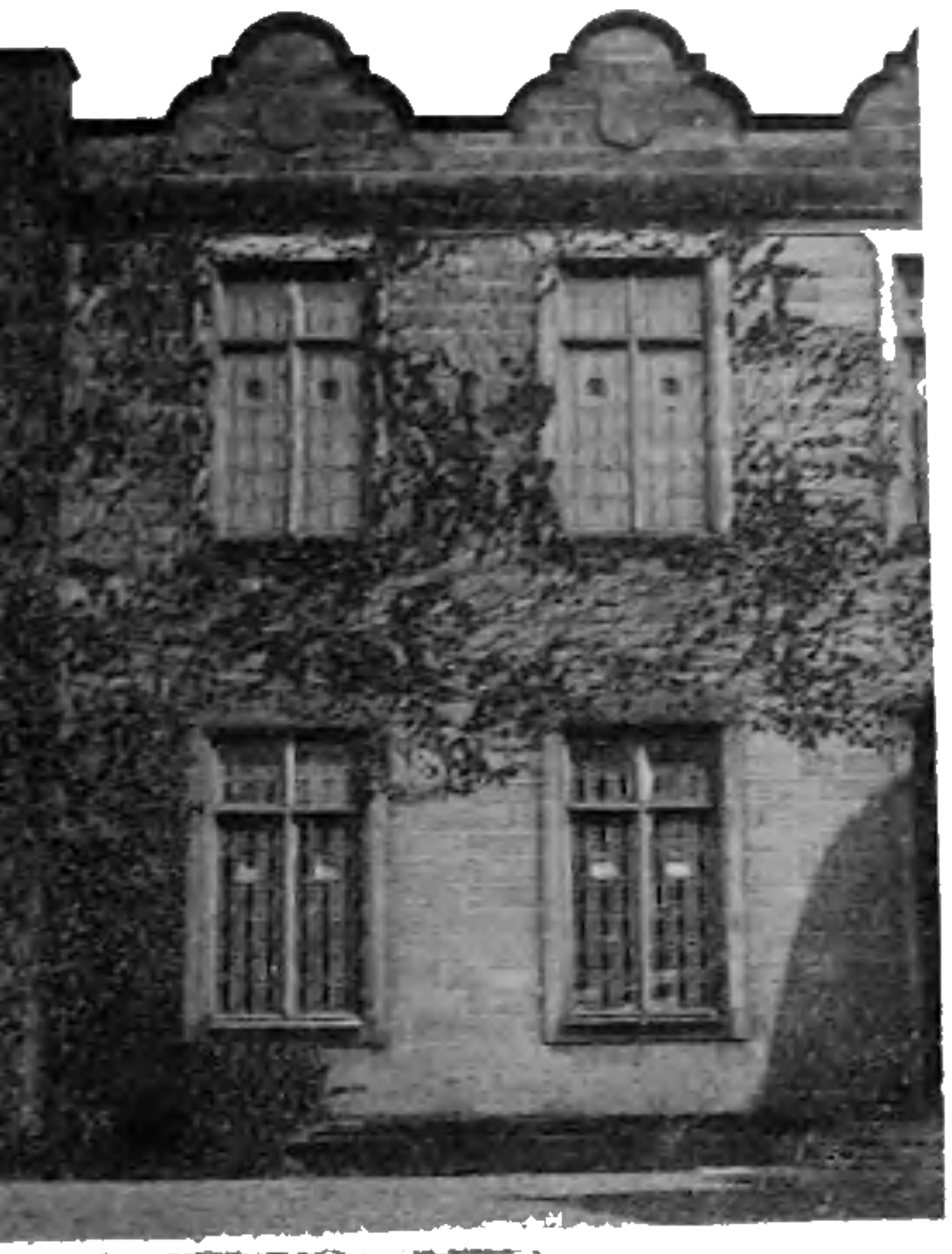


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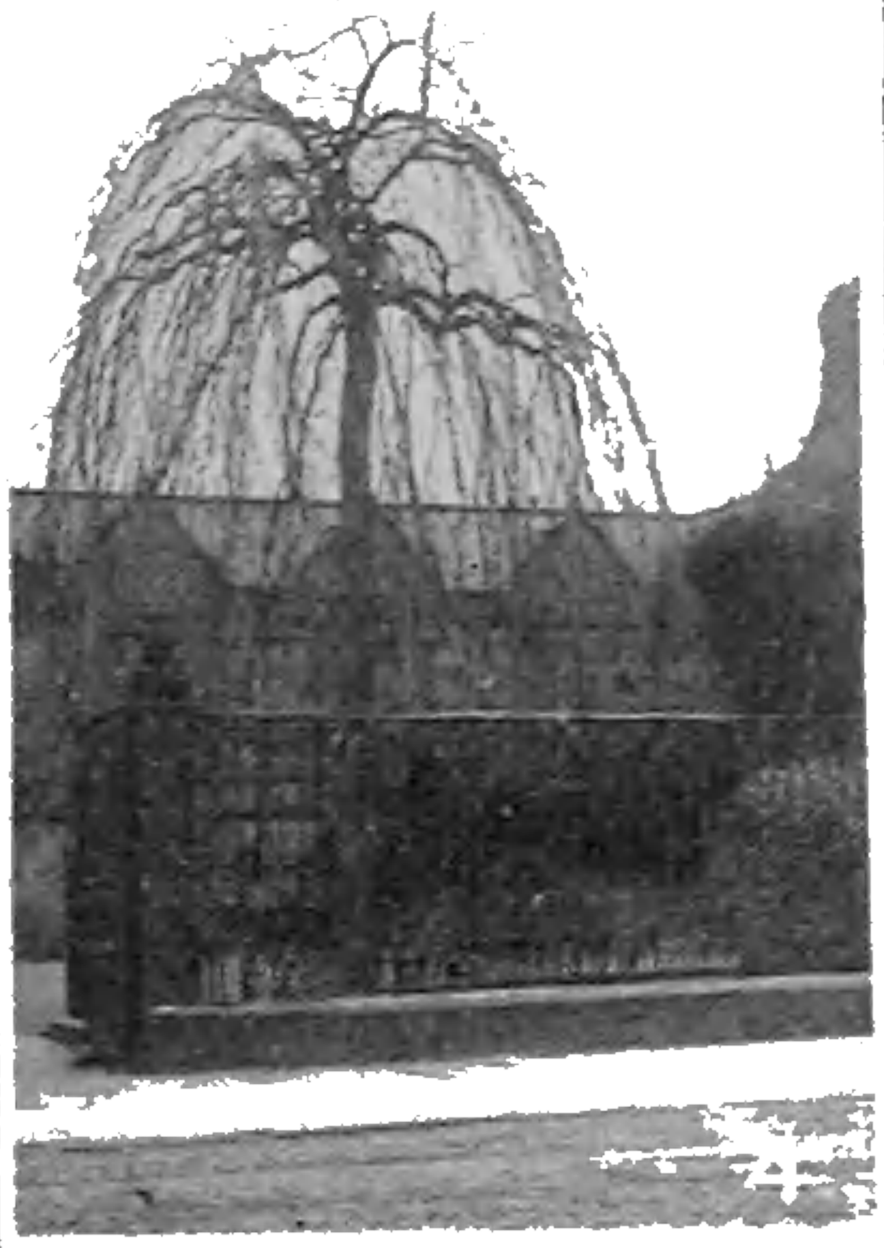


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NATURE STUDY RAMBLES ROUND ST. ANDREWS.

Chapter I.

In the City.

St. Andrews has not been without its votaries in the Natural Sciences. It is not possible here to tell of all the naturalists who have helped on the good cause. They fall under two classes—the Town and the Gown. As members of the former I might particularise the late Messrs. Wm. Fernie Buist, Charles Howie, and George Bruce, and of the latter Professor M'Intosh and the late Professor Heddle. So far as Biology is concerned, it may well be said that Professor M'Intosh's promotion to the Chair of Natural History in the University of St. Andrews marked a period of revival and progress which is culminating in great things for the University, one of the most important being the erection of a splendid museum, the gift of Mrs. Bell Pettigrew, in memory of her husband, the late Professor J. Bell Pettigrew, F.R.S., himself a naturalist of the first rank.

The present University Museum has until quite recently been the joint property of the University and the Literary and Philosophical Society of St. Andrews. It is of much interest to recall that in the circular issued by the promoters of the Society, convening the first meeting, the following names, among others, are given as signatories: Dr. John Adamson, Sir David Brewster, Major H. Lyon Playfair, Principal Robert Haldane, Rev. George Buist, D.D., Rev. Chas. J. Lyon, and Mr. John Bain. Dr. Adamson, for long an esteemed physician in the city, and one whose name is closely associated with the advance of the science of photography in its early stages, seems to have been particularly active in founding the Society. Its membership roll contains the names of many distinguished men, of whom one is Sir John Lubbock (Lord Avebury), now Rector of the University, and who connected himself with the Society at so early a date as 1841. Announcements of local discoveries of much importance are to be found in its records.

It is fitting to mention here the name of Mr. Alexander Thoms, F.R.S.E., who has held the post of Hon. Secretary of the Society for the past twenty years, and for whose labours in arranging for the publication of Professor Heddle's exhaustive work on the Mineralogy of Scotland the thanks of all Scottish naturalists are due.

In antiquarian and historical research, often cognate, in St. Andrews, with the pursuit of the Natural Sciences, the name of Dr. Hay Fleming stands pre-eminent.

The University Museum has, under the direction of Professor M'Intosh, become a storehouse of material of great value to the home naturalist, and a visit to it cannot but be highly instructive. On all sides will be noted the evidences of Professor M'Intosh's life-long devotion to Zoology, and his profound knowledge of the fauna of St. Andrews Bay. Amongst the great variety of objects pressing for remark, I might particularly instance the unique series of preparations which illustrate the development of the food-fishes, the outcome of work which engaged the energy of Professor M'Intosh himself and his assistants for several years. The splendid

familiar as *A. hederacea.* Some authorities think that these plants are not sufficiently distinct from the Grape-Vines to justify the use of any other generic name than *Vitis.* Under this nomenclature we accordingly find the Japanese Ivy designated *Vitis inconstans,* and the Virginian Creeper *V. hederacea.*

It is obvious that they are Vines, closely associated with *Vitis vinifera,* the varieties of which are so familiar in our vineries. If a shoot of a **Grape-Vine** be compared with corresponding shoots of the climbers we are studying, an instructive series is formed. All three display beautiful red coloration when the leaves are fading, the Japanese Ivy being the most brilliant. The leaves are all formed on the same general pattern. In the Grape-Vine the lobes are comparatively shallow, while in the Virginian Creeper the divisions reach the base of the blade. In the Japanese Ivy both forms may be seen, and, indeed, many leaves can be found with a shallow lobe on one side and a separate leaflet on the other.

It is the tendrils, or apparatus employed in clinging to supports, that interest us most. In the Grape-Vine it is easy to observe that the tendril arises at a point on the shoot on the side opposite to a leaf—not, as one might naturally expect, in the axil of a leaf. Some authorities have tried to show that this peculiarity is due to cohesion of the branch constituting the tendril with the axis from which it arises, the union extending the length of a node before freedom is gained. Others have held that the tendrils are to be regarded as main axes which are pushed to one side, their place being taken by successive lateral branches which go to form the straight shoot. That the tendrils are really branches can be readily demonstrated; they, for instance, bear leaves occasionally. Their proper function is to act as climbing organs, and this they effectively perform by twining round supports which happen to be conveniently near. Their coils may be seen in numbers firmly wound round the trellis-wires of a vinery roof.

An inspection of the tendril of the **Virginian Creeper** shows a remarkable advance on that of the Vine. In the first place, it is much branched, and might therefore be held to have a better chance of finding a support, but the branching is soon seen to be connected with a different function than spreading in quest of objects round which to cling, as the whip-like tendril of the Vine does. A considerable number of the branches bear flattened knobs at their tips. The knobs are well developed before they touch anything, and their objective is clearly something against which they may further flatten themselves. If circumstances are favourable they are pressed against some solid body, and the pressure, aided by the exudation of a cement, causes them to adhere firmly. Previous to the attachment of the discs torsion is exhibited in the tendrils, and, as a result of its continuance, marked spiral twisting is set up in them. When the twisting has proceeded to a certain degree a double spiral is necessarily produced, one half-length being turned to the right and the other to the left. The Virginian Creeper has too few disc-bearing tendrils, or is lacking in promptitude and power in fixing what it does have, and its climbing capabilities are therefore second-rate. Its foliage is large and bulky, hence it is often necessary to assist the clinging by putting up stakes or trellis-work against the wall.

The **Japanese Ivy** is absolutely independent of extraneous aid as a climber. The tendrils are seen to occupy the same position as in the above. They are much branched at their extremities, and all the branchlets turn naturally away from the sunlight and press against the stones of the wall. They are all terminated by discs, and the cement they exude is perfect of its kind, for the discs remain firmly adherent to the wall if the branchlets which produced them are ruptured by a hard enough pull. In this feature of resistance they bear a singular resemblance to the discs produced at the adherent ends of the threads of the beard or byssus of the Common Mussel, a structure to be described in a later chapter.

The resemblance of the Japanese Ivy to the **Common Ivy** (*Hedera Helix*), of which several varieties are to be seen in the quadrangle, is greatly enhanced by the appearance of innumerable aerial roots on its older stems. These roots arise on opposite sides of the stem in the plane of the wall, and are accordingly entirely different in their function from those of the Common Ivy, whose aerial roots arise on the part of the stem nearest the wall. Further, the aerial roots of the Japanese Ivy exercise no climbing function, and never come into contact with the wall, whereas those of the Ivy, as everyone knows, are stuck to the wall, and are the organs by which alone it climbs. The Ivies can claim kinship with the Vines, but it is remote at best.

The production of aerial roots is a very common phenomenon in the Grape-Vine, when the atmosphere in which it is grown is kept unduly charged with moisture. Such roots hang more or less vertically in a tufted fashion.

The disposition of the branches and shoots of the Japanese Ivy exhibits striking regularity, being admirably suited to prevent overlapping, and to occupy the available space with respect to light and air to the best advantage.

Other plants employed to decorate the quadrangle are the two Japanese shrubs, *Euonymus japonica variegata* and *Pyrus (Cydonia) japonica*, the Japanese Quince. We are thus further reminded of our great indebtedness to Japan for many of our most ornamental garden plants. It may be mentioned as an interesting fact in plant distribution that we have a native relative of the above

Euonymus in our Spindle Tree (*E. europæus*), found wild in several places in Scotland, and common in England.

In North Street, at the east end of St. Salvator's Chapel, there is a somewhat unkempt shrubbery (Plate I., fig. 7). Confining our attention to the part close to the street, we note first the tallest tree there. It is the **Heart-leaved Alder** (*Alnus cordifolia*), a native of Italy. When, in the spring time, the tree bears its flowers, it is an object of considerable interest. The flowers are of two kinds. The male or staminate ones are borne in a narrow, cylindrical mass which falls in a piece when the fertilising function is performed, the inflorescence being thus a true catkin. The seed-bearing inflorescences are at first very much smaller, but they develop into oval cones which persist, and may be seen on the tree after the leaves have fallen. The cones are composed of woody scales arranged in pretty spirals. The leaves are of such shape and texture as not to be readily mistaken for those of any other tree we may meet with.

A feature of much interest is to be noted in the roots of this Alder and others, namely, the presence of peculiar coral-like excrescences composed of minute lobules or tubercles which are inhabited by a fungus which has been named *Frankia alni*. An example of an excrescence seen on the root of the present tree measured 3½ inches in diameter. It lay immediately beneath the surface of the ground. The relationship of the fungus to the tree is described as symbiotic—that is, a living together of two organisms in a mutually beneficial manner. It has been stated that the fungus is of advantage to the Alder as the provider of certain nutrient materials resulting from its activities.

A fine example of *Alnus cordifolia* is to be seen in Queen's Gardens, and I think there used to be another in the enclosure at the Town Church.

The most familiar species to us is the **Common Alder** (*Alnus glutinosa*). Its ordinary habitat is the banks of our rivers and burns, where it often attains to a considerable height. The lobulated excrescences referred to can always be found on its roots. This species prefers to grow in damp places, whereas *A. cordifolia* is adapted for growing in dry soils.

Another tree in the enclosure is the **Horse Chestnut** (*Æsculus Hippocastanum*). Its massive buds, hoof-shaped leaf-scars, digitate leaves, erect inflorescences, globular, spinose fruits, and large brown seeds are all objects worthy of more than passing note.

Lilac is also represented. It is known botanically as *Syringa vulgaris*, and it is classed in the Olive order (*Oleaceæ*). Alongside of it is the shrub popularly called **Syringa** or **Mock Orange,** a plant having no family connection with Lilac. Its botanical name is *Philadelphus coronarius*, and it is placed in the Saxifrage order. Two interesting points in this showy shrub may be noted, namely, that the terminal flower in each tuft has five petals in place of the usual four, and the leaves have a flavour of cucumber. Privet, another member of the Olive family, and a native of England, is present.

An old specimen of a **Gean Tree** also occupies the enclosure. The leaf of the Gean is ovate-elliptical, with serrate margins. The leaf-stalk is cherry-red, and bears two glands placed on the opposite edges of the upper side, close to the blade. Besides those glands, the majority of the teeth of the leaf margin are terminated by smaller glands.

A **Laburnum** occupies a corner. It may be mentioned here that an interesting derivative of Laburnum is to be found in several places in the neighbourhood, namely, *Cytisus Adami*. When fully developed it bears branches of three kinds on one stem—the Common Laburnum

(*Laburnum vulgare*), a small shrub with solitary, axillary, purple flowers (*Cytisus purpureus*), and a hybrid between the two, with flower-shoots of the form of Laburnum, but reddish (*Cytisus Adami*). In most specimens the mistletoe-like tufts of the purple-flowered shrub are absent, and there is usually a strong tendency on the part of the Laburnum to assume the ascendant over the red-flowered hybrid. This remarkable composite tree originated about eighty years ago in France, as the result of budding *Cytisus purpureus* on a stock of the Common Laburnum. It is accordingly designated a graft-hybrid.

In Market Street we find, on both sides of the street, young specimens of an Elm quite distinct from the tree we have already studied, the habit being much more erect and the leaves much smaller. This is the **Common Elm** (*Ulmus campestris*). Previous to the planting of the Elms an experiment was made by planting in the same place specimens of one of the Maples (*Acer dasycarpum*), but they refused to grow.

Crossing to South Street, those who knew the environs of the old Town Church miss the fine **Weeping Elms** which overhung the pavement. Good specimens of the same tree may still be seen in Bell Street, the Cathedral Burying-ground, and other places.

A number of very fine **Weeping Ash** trees are to be met with in the city. A pair, one on each side of the ruin of the Black Friars' Monastery (Plate I., fig. 4), are specially striking. They were, I believe, the outcome of the skill of the late Charles Howie, who, if my memory serves me aright, trained the saplings for the purpose in Stravithie Den. The method pursued in producing those graceful trees is to insert a number of grafts of the "weeping" variety at the top of a tall sapling of the ordinary type. The bole thus consists of one variety and the drooping branches of another. Dr. Hay Fleming tells me that the above were planted by Mr. Howie about forty years ago, and that they were supported by ropes for a considerable time after planting.

Other examples of the Weeping Ash, evidently of the same age and origin, are to be seen at Hope Park U.F. Church, St. Mary's Place, in St. Mary's College quadrangle, and elsewhere.

Fine specimens of Ash trees of the ordinary type can be seen near the west entrance to the Madras College quadrangle.

The **Lime** or Linden trees (*Tilia vulgaris*) which are now so great an ornament to South Street (Plate I., fig. 8) were planted in the spring of 1879, at the suggestion of the late Bailie John Milne, a gentleman whose keen æsthetic tastes are seen reflected in many other parts of the city and vicinity. The trees on the north side were the first to be planted. They were at planting about twenty feet in height, and finely formed. The south side of the street was planted a year later, but the trees available were not so good, and the situation not so sunny, hence the lack of uniformity in the size and shape of the trees there.

It may be mentioned that the Lime trees in Market Street, in front of the West End (Infant) School and West Park, were planted at the instance of the late Captain Stewart of West Park a few months before the South Street trees.

Three much older Lime trees stand together within the enclosure of the Town Church, their position having admitted of their preservation at the rebuilding.

The Lime is easily recognised by its smooth, oblique leaves. I am not aware that flowers have ever been noticed on any of the trees in the street. Where such are found, they are interesting on account of the peculiar bract which forms a wing to the flower-stalk.

Large specimens of the Common Ash stand in line in the roadway to the east of the church. They formed the eastward continuation of the line in the Long Walk in the grounds of St. Mary's College, before the public road was made through the south end of the grounds.

In the quadrangle of St. Mary's College the most interesting object is the so-called **Queen Mary's Thorn** (Plate I., fig. 3). It is certainly a very aged tree, but I am not aware of any verification of the tradition that it was planted by Mary Queen of Scots. Messrs. Jeffrey and Howie, in the 'Trees and Shrubs of Fife and Kinross' (1879), give the following notes: "In the court of Mr. Stirling's house, near the Cathedral ruins, there is an old tree, known as 'Queen Mary's Thorn.' Its girth is 5 feet 9 inches, its stem 11 feet, its height 43 feet, and its diameter of branches 39 feet 6 inches." Referring to St. Mary's College they remark: "A tree at the bottom of the court, also of the Queen's planting, has a girth of 6 feet 4 inches, a stem of 9 feet, a height of 48 feet, and a diameter of branches of 48 feet." At present the girth, at 3 feet from the ground, is 7 feet. A stump rising from the ground on the south side close to the present stem, and a shoulder on the east side near the ground, seem to indicate the loss of parts there. A print of the quadrangle, dated 1767, shows the tree to be standing on the south side of a wall which separated the present court from the rest of the grounds.

Loudon, in 'Trees and Shrubs,' makes the following entry regarding a variety of Hawthorn: "*Cratægus Oxyacantha reginæ* Hort., Queen Mary's Thorn. The parent tree is in a garden near Edinburgh, which once belonged to the Regent Murray. It is very old, and its branches have somewhat of a drooping character; but whether sufficiently so to constitute a distinct kind appears to us very doubtful."

On Nov. 14, 1893, the old tree at St. Mary's College was uprooted and laid flat by a gale. It seemed as if the end had come, but the veteran was raised up, supported by beams, and fresh soil laid about its roots. Since then it has renewed its youth in no small measure, and it is to all appearance as fresh as it ever was.

Besides the ancient white Hawthorn, a red-flowered one, still a bush, occupies a place on the north side of the quadrangle. It originated as a seedling on the top of the wall—recently removed—close to Queen Mary's Thorn, and was transplanted to its present position. It would be rash to assume that it is a seedling from Queen Mary's Thorn.

A dark-leaved tree occupies the centre of the quadrangle. It is an **Evergreen Oak** (*Quercus Ilex*), a native of the south of Europe. It is distinguished from our own Oaks in retaining its foliage all the year round. This tree suffered great damage from a gale in December, 1900, and it presented a dilapidated appearance on the south side for a time. Means were taken of binding the remaining boughs together, and it is gratifying to notice that the gap is being gradually occupied by new foliage.

Among the climbers on the walls of the College and Library the following may be mentioned: *Clematis montana* (Himalayas), *Escallonia macrantha* (Chiloe), *Ceanothus Veitchianus* (California), *Euonymus radicans* (Japan), *Cotoneaster microphylla* (Himalayas), and *Jasminum officinale* (India, Persia).

Clematis montana is possessed of climbing apparatus different from those already described. The leaf-stalks function as tendrils. They are highly sensitive, and grip objects of a suitable size with great vigour. Their coil is not a simple turn, but rather of the nature of a hitch, which renders the hold all the more effective. When supports are not present, the trailing stems are held together in fascicles, and in this way acquire a certain rigidity which helps greatly to keep the plant up.

On the east side of the Long Walk there are two good examples of the **Red Chestnut** (*Æsculus Pavia*). This species flowers at the same time as the Horse Chestnut, and although the panicles are looser and not so erect, the tree is very attractive when in bloom. A small specimen of the **Spanish** or **Sweet Chestnut** (*Castanea sativa*) is growing near. It does not belong to the same family as the Horse Chestnut.

During the past twenty years the grounds of St. Mary's have undergone great transformation. A significant change took place when the first **Botanic Garden** connected with the University was made at the south-east corner. This garden (Plate I., fig. 6) was opened on June 28, 1889, by Professor M'Intosh, in presence of a large company of ladies and gentlemen, including Dr. H. Cleghorn, Professor J. Bell Pettigrew, Professor P. R. Scott Lang, Rev. Mark L. Anderson, D.D., Mr. Alexander Thoms, Mr. Charles Howie, and others interested in the equipment of the Botanical Department in the University. The following account of the proceedings is taken from a report which appeared in the press at the time:—

"The central portion of the garden is occupied by oblong beds surrounded by grass. These, 83 in number, are filled with plants representing a corresponding number of natural families, and they vary in size according to their relative importance. Between 700 and 800 species of plants have, up to the present, been put into the beds. The beds are arranged in such a way as to show the recognised sequence from lower to higher forms. The disposition of the rows of beds will also help the student to grasp, at a glance, the relationship of the classes and greater divisions. The arrangement, in short, reminds one of a chart. The student and the tyro in the science of Botany can thus pursue the study of the systematic side of the subject with the minimum of trouble. It is an interesting feature in itself to note in the beds the different regions of the globe from which the members of any one family are drawn. For example, in the Lily family, species are side by side from Canada, Siberia, Japan, Nepaul, Cape of Good Hope, New Zealand, Persia, Portugal, Switzerland, Scotland, and elsewhere.

"Professor M'Intosh, in opening the proceedings, said that it was arranged that Principal Donaldson would preside, but being occupied in London, he was unable to be present. Botany, he said, was no new subject in the University, although a Botanic Garden was a novelty. The foundation of a lectureship, and the formation of a Botanic Garden, had long been before the University. The site for a Garden had more than once been chosen. He might refer, for instance, to that now occupied by the New Cemetery. With all deference to those who chose that site, he thought it would not have been so suitable as the present one, having in prospect the extension of its boundaries westward so as to incorporate the fine grounds pertaining to St. Mary's College. The development of the scientific side gave new life to the University. Steps were taken some years ago to have lectureships in connection with a two years' medical course in St. Andrews. The difficulties in the way chiefly arose from the want of money—no unusual thing in University life in our country. While these difficulties were so great, no progress was made; but just at this juncture Dr. J. Wilson volunteered to give a course of lectures, with the sanction of the University. Having started the lectureship, the next point was to have a Botanic Garden. Dr. Wilson took the Garden in hand, and they now saw the wonderful transformation made on it. He had been generously and ably assisted by a student of his own—Mr. Thomas Berwick.

"Dr. Cleghorn of Stravithie said he was delighted to see this important addition to the teaching powers of his *Alma Mater*. He was surprised to see such a display of plants, considering the short time the Garden had existed; and he heartily joined Professor M'Intosh in his appreciation of the efforts of those who had planned and planted it.

"Professor Pettigrew said that he thought the day would be a red-letter day in the University. In one sense, the Garden was a creation of Professor M'Intosh's, seeing that he, in so large a measure, had had the training of Dr. Wilson."

In 1899, when the Bute Medical Buildings were erected, it was found necessary to encroach on the Garden, and a new arrangement was planned by Mr. R. A. Robertson, the present Lecturer on Botany. The handsome museum, the gift of Mrs. Bell Pettigrew, in course of erection in communication with the Bute Medical Buildings, has again rendered rearrangement necessary, and the whole of the available space in front and behind will before long be utilised for botanical purposes, thus realising the anticipation expressed by Professor M'Intosh twenty years ago.

In some of the private gardens in South Street, trees of considerable interest can be found. A Yew, centuries old, adorns one garden. In another a very aged Mulberry, although prone, still bears good crops of its peculiar raspberry-like fruit. Near it grow two specimens of the Maiden-hair Tree (*Ginkgo biloba*) of considerable age. This plant is of unusual interest to botanists, because it has been shown to be a connecting link between the Conifers and the Cycads.

In front of St. Leonards Chapel there is a large specimen of the **Strawberry Tree** (*Arbutus Unedo*). Its flowers are like heather-bells, and it blooms quite freely.

The fruits resemble the strawberry in outward form only. The Strawberry Tree is an ally of the Heaths. It is a native of Britain, and one sees fine examples of it on the islands in the Lakes of Killarney.

A tree not unknown to fame used to occupy the garden of the house next the Pends, and now called Prior's Gate. In 1773 Dr. Samuel Johnson and Mr. James Boswell visited St. Andrews. The city was by no means so umbrageous then as it is now. The following are Dr. Johnson's reflections on the lack of arboreal vegetation in our neighbourhood: "From the bank of the Tweed to St. Andrews I had never seen a single tree which I did not believe to have grown up far within the present century. . . . There is no tree for either shelter or timber. The oak and the thorn is equally a stranger, and the whole country is extended in uniform nakedness, except that in the road between Kirkaldy and Cowpar I passed for a few yards between two hedges. A tree might be a show in Scotland as a horse in Venice. At St. Andrews Mr. Boswell found only one, and recommended it to my notice; I told him that it was rough and low, or looked as if I thought so. 'This,' said he, 'is nothing to another a few miles off.' I was still less delighted to hear that another tree was not to be seen nearer. 'Nay,' said a gentleman that stood by, 'I know but of this and that tree in the county.'"

In a pamphlet on "The Great Maple," by the late Mr. C. Howie, the following notes regarding the above occur: "We suppose he must have intended to say that these two eclipsed all the others. They were both Great Maples. One of them stood behind St. Leonard's Chapel in St. Andrews. It is said to have had a most striking appearance—more from the outspread of its branches than from its height. In those days tea-parties often took place under its canopy in the summer evenings. A wooden platform was placed over the lower branches, and it was approached by a wood-laid gangway. The other tree to which Dr. Johnson alludes grew at Priorletham, about three miles from St. Andrews. In 1818 this tree was still standing, but in a state of decay. At that date it showed a clean stem of 12 feet under the branches, with a girth round the base of 20 feet, and, at 6 feet up, 15 feet 4 inches—the ten principal branches appearing as trees, several of them 2 feet in diameter. The height of the tree was 65 feet, the spread of branches from side to side was 95 feet—thus making a goodly shade 300 feet in circumference."

The Priorletham tree is thus briefly referred to by Messrs. Jeffrey and Howie in 'Trees and Shrubs of Fife and Kinross': "The other tree stood by the side of the entrance to Priorletham (the Priors' Morass). This tree is noticed in a lease as the 'big tree.'"

Boswell's own reference to the incident is as follows: "We went and saw Colonel Nairne's garden and grotto. Here was a fine old plane tree. Unluckily the colonel said there was but this and another large tree in the county. This assertion was an excellent cue for Dr. Johnson, who laughed enormously, calling me to hear it. He had expatiated to me on the nakedness of that part of Scotland which he had seen. . . . I know not how Colonel Nairne came to say there were but *two* large trees in the county of Fife."

Lyon, in his History of St. Andrews (1838 ed.), states that Colonel Nairne's tree "stood in the garden belonging to the late Mr. Binny, at the east end of South Street."

At the time of Dr. Johnson's visit St. Leonard's Chapel was being put to a peculiar use. He remarks: "A decent attempt, as I was since told, has been made to convert it into a kind of greenhouse, by planting its area with shrubs. This new method of gardening is unsuccessful.

the naturalist looks from that lofty platform a rich field for exploration fills his vision. The bird's-eye view comprises a survey of all the routes we propose to follow in the subsequent chapters. A portion of the panorama is shown in Plate I., fig. 2, where, looking to the south-east, we see the upper harbour, the Bents, and the East Sands, with Kinkell Braes in the distance.

PLATE II.

FIG.

1. View in St. Leonards School Grounds: A, *Garrya elliptica;* B, *Cordyline (Dracæna) australis;* C, New Zealand Flax; D, Pampas Grass.
2. Vegetation on the top of the Abbey Wall.
3. Excavation for Gasholder in St. Leonards Grounds.
4. Abbey Wall, with False Acacia (*Robinia*) and ivy-covered tower.
5. Bulbil-bearing head of Crow Garlic, showing effect of cultivation.
6. View of the Provost's Garden.
7. Bulbil-bearing head of Crow Garlic—the normal condition.
8. Part of the Abbey Wall, with Wallflower in the niches.
9. Wall-rue Spleenwort (*Asplenium Ruta-muraria*).
10. Pistillate catkin of *Garrya elliptica.*
11. Staminate catkins of *Garrya elliptica.*

PLATE II.

Chapter II.

St. Leonards.

The grounds to the south of the site of the old St. Leonards College formed the once famous **Provost's Garden.** Sir Hugh Lyon Playfair took delight in making his garden unique as a combination of instruction and recreation. The older inhabitants remember it chiefly by its quaintness, but there are those who associate with it much that was highly educational. The upper, more private, part was chiefly devoted to decorative gardening, and several of the trees and the vases which were familiar to Sir Hugh are still existent. The lower part was the haunt of visitors, and many interesting and curious products of the Provost's fancies, interspersed with fine examples of fruit- and flower-gardening were there. The most prominent object in the garden was the so-called Temple (Plate II., fig. 6), a tall pagoda-like structure of open wood-work, with platforms reached by ladders. The view from the platforms was very fine. The handsome erection here figured was succeeded by a somewhat less imposing one. The mill-lade, a streamlet which, until comparatively recent times, was open for the greater part of its length from the Law Mill to the Abbey Mill and the harbour, ran under the Temple, and an undershot water-wheel pumped sufficient water up into elevated cisterns to supply a series of fountains placed at intervals along its course. Dispersed about the walks were models of orreries, with labels setting forth at a glance the distinctions of the chief planets. One of the walks was edged with a continuous rail on which was painted a chronological table to record events which happened from the year "one" onwards. The rail consisted of short parts laid on posts at a height convenient to read. The divisions resembled a scale, short lines representing single years, and longer ones the decades and centuries. The event chronicled occupied a position opposite its appropriate line. A feature characteristic of the Provost's idiosyncrasy was to be noted, the spaces beyond the date of the Reform Bill of 1832 being left blank. The inference to be drawn by the reader was, I believe, that nothing was worth recording after so great a blunder as that. The descendants of the Fuchsias which hid the supports of the chronological table are now flourishing on the rockery. They are liable to be cut down, although not killed outright, by severe winter frosts. Several contrivances driven by water, or otherwise illustrating hydraulics, such as the Archimedean Screw and the Barker's Mill, were to be seen at work. Small aquaria for both fresh water and marine life were also kept for the instruction of visitors.

It may be mentioned that the tombstone-like monument erected to commemorate the martyrs who suffered death at St. Andrews, now forms a base for one of the vases that used to decorate the top of the dividing wall which ran westwards from the corner where the stone is now placed.

The central Lime tree, the large Evergreen Oak, and several old Hollies are much the same in appearance as when the garden was in its pomp; and the large double red Hawthorn and its companion, the Purple Beech, seem but little larger than when they overshadowed the stream and the bridge on which was inscribed, "Tread on it and

or no rain falls there for several months in summer, but dense mists roll in daily from the Pacific and afford coolness and moisture which keep the mountain plants green and flourishing when all the vegetation in the lower levels, with the exception of evergreen plants, including oaks, are withered up.

Eccremocarpus, like Garrya, has no British relatives. It is a native of Chili, and is one of our prettiest flowering climbers. The waxy, orange flowers are borne in trusses of a good size. The leaf is compound, and its terminal leaflets are modified to serve as tendrils. They resemble fine threads, and when they fail to lay hold of supporting objects they wind themselves into close coils. The same kind of tendril is to be found in the garden pea, but in that plant the twining threads are very much coarser.

Memorial trees, of comparatively recent planting, comprise varieties of Maples, the Weeping Birch, and a peculiar variety of Ash, *Fraxinus excelsior* var. *monophylla*. The majority of the leaves of this Ash are simple and ovate, while many bear an additional pair of small leaflets.

The effect of shelter is strikingly shown by the health and stature of a trio of interesting plants which stand together—viz., *Cordyline (Dracæna) australis*, the New Zealand Flax (*Phormium tenax*) and the Pampas Grass (*Gynerium argenteum*) (Plate II., fig. 1 B, C, D). They are from countries so far apart from one another, and from us, as Australia, New Zealand, and South America. The **Dracæna,** a plant commonly found in pots and tubs in greenhouses in our latitude, is in perfect health. It was planted some twelve years ago. The height to the tips of its leaves is 12 feet, and its stem 7½ feet. It receives no special protection in the winter time. Two plants of the same species which I planted in the University Botanic Garden were killed by frost after they had weathered only one or two winters. They were in rather too rich soil, and consequently by over-luxuriance more than usually tender.

The **New Zealand Flax** has formed a large clump. The largest leaves are 6 feet long and 3¼ inches broad. They are easily torn lengthwise and the flaxen fibres exposed. Flowers are produced in plenty. The flower-masses rise in height to over 7 feet. The individual blooms are narrow-throated, dark crimson bells, of very firm texture. The tube is about 1½ inch long, compressed and curved upwards slightly. The stamens and style project beyond the lip half an inch. Probably self-fertilisation takes place, the stigma being in close proximity to the stamens, and the pollen abundant. Insects may assist in the process. Humble-bees visit the flowers, and honey is secreted copiously. In fine seasons a very large yield of fruit is produced. The capsules are black, three-cornered, and 2 to 2½ inches in length. The seeds are deep black, shiny, wafer-like, and packed together in three tiers.

This clump was raised from seed saved in Orkney by the late Dr. William Traill, of Woodwick, a gentleman long known in St. Andrews as an assiduous naturalist.

Mention may be made of the fact that other seedlings from the same source were grown in the garden of the late Mr. William Walker, Strathkinness, three miles inland. They were even more robust than the St. Leonards plants. The seed they produced was quite normal, good plants being grown from it. Mr. Walker's plants received no shelter, and many of their leaves were snapped when frozen, or torn into shreds by the wind.

The plants at present in the University Botanic Garden were grown from seed saved at Strathkinness.

It is noteworthy that the Dracæna and the New Zealand Flax are both representatives of the same great natural order, the Liliaceæ, an order most familiar to us by its bulbous genera, which include our Wild Hyacinth and many other native plants.

The **Pampas Grass** is quite hardy. Here it has produced a dense clump 3 feet in diameter. The mass is largely composed of persistent withered and dead leaves, from amongst which the growing crowns emerge. The longer leaves are from 5 to 6 feet in length. They are provided with minute, sharp prickles pointing forward along the edges and median ridge. It is rather disconcerting to be told by a recent authority that in spite of its long-established popular name, this plant does not really flourish on the Pampas, but in the mountainous regions of South America, growing best in hollows where the supply of water is sure.

An Acacia tree, so-called, stands beside the trio of specimens described. It is not a true Acacia, of which many species are to be seen in conservatories, natives of Australia and elsewhere. Our plant is the **False Acacia** or **Locust** (*Robinia pseud-acacia*), a native of eastern North America. At the lower end of the Garden there is a larger specimen of the same species (Plate II., fig. 4, left side). This old tree seems the same to-day as it was thirty or forty years ago. It is extremely late in coming into leaf, and it now makes very little annual growth. The foliage is pretty, resembling in the pinnate arrangement of its leaflets that of many other members of the pea tribe. The stipules are transformed into thorns which persist in many cases for a considerable time, and render any attempt to climb the tree an unpleasant experience. The flowers of this species are borne in drooping racemes like Laburnum, but their colour is white, and they are fragrant. This tree has not been known to flower for many years until recently, when special nourishment led to the development of a few flowers.

In the grounds of the old house are also to be found examples of the following: the Corstorphine Plane, Walnut, and *Diervilla florida (Weigela amabilis)*; and at Bishop's Hall grounds, on the west wall, *Ribes speciosum*, *Forsythia suspensa*, *Vitis Coignetiæ*, *Jasminum nudiflorum*, *Cratægus Pyracantha Lelandi*, and *Ceanothus* "Gloire de Versailles."

The Corstorphine Plane is a variety of the Great Maple with leaves which remain yellow for a considerable time in the spring and early summer. The Weigela is the same bush which used to cover the gateway between the upper and lower gardens in Sir Hugh's time. Interesting notes could no doubt be made of the other plants mentioned, but we may single out two for remark. *Ribes speciosum*, a native of California, related to the Gooseberry, compels attention when in flower, its blossoms being uncommonly like the Fuchsia. They are pendent, scarlet, with long stamens of the same bright colour. *Vitis Coignetiæ* is a very robust plant, with attractive bronze, rugose, broadly trilobed leaves, and long, strong tendrils which branch to some extent and constitute efficient climbing organs.

Amongst the weeds which are apt to grow here as well as in places where they get more quarter, special note should be made of a rather rare one in this district—the **Hoary Plantain** (*Plantago media*). It has for many years been a denizen of this ground, and its presence in the lawns is not to be desired. Compared with its congeners, the Greater Plantain (*Plantago major*) and the Ribwort Plantain (*P. lanceolata*), also present in the lawns, it is a highly aggressive species. Its leaves are large and they lie very flat, thereby being missed by the lawn-mower. When in flower the purple tint of the long stamens gives a certain air of attractiveness foreign to the Plantains in general.

The flora of the Abbey Wall affords us material for study. The most familiar plant is the **Wallflower.** For how many centuries this plant may have graced the old walls we have no record, but it has certainly done so ever since Robert Fergusson's time. Reference is made to it in Fergusson's poem inscribed "To the Principal and Professors of the University of St. Andrews, on their superb treat to Dr. Samuel Johnson":—

> "St. Andrews town may look right gawsy,
> Nae grass will grow upo' her cawsey,
> Nor wa'-flowers of a yellow dye
> Glour dowy o'er her ruins high,
> Sin Samy's head, weel panged wi' lear,
> Has seen the Alma Mater there."

Examples are to be seen growing where anything of the nature of soil seems out of the question—in fact, in mere chinks of the masonry, and in the full blaze of the sun. Such plants are dwarfed and woody, and very different indeed from the tall and fairly herbaceous specimens grown in the rich soil of our gardens. The vicissitudes of a hard upbringing, however, tend to longevity on the part of the plants on the wall. The flowers are a bright pure yellow, and seed is borne in abundance. Fine plants are to be noticed in the niches of the towers and other places where a shelf of stone has sufficed for the accumulation of a handful or two of wind-blown soil (Plate II., fig. 8).

On the old wall near the greenhouse in Bishop's Hall grounds a few plants of Wallflower were noticed lately amongst the typical wildings with much deep-brown red in their flowers. One of them was as deeply coloured as certain dark varieties, identical in fact with a specimen grown in front of St. Leonards House, having the petals rich red underneath, and finely veined with the same colour on the upper side. The probability is that those plants were the result of crossing by insects with dark varieties in the garden borders beneath.

Near by, on the face of the wall, a strong plant of Scurvy Grass (*Cochlearia officinalis*) has found a home.

An inhabitant of the wall much less familiar than Wallflower to the passer-by is the **Crow Garlic** (*Allium vineale*), yet it is found almost everywhere amongst grassy vegetation on the ruined ridge. It occupies the wall from the Turret Light to the tower opposite the Burgh School. A particularly strong patch grows on the top of the tower in the Eastern or New Cemetery. This plant occurs nowhere else in the neighbourhood of St. Andrews. The wall is from 18 to 20 feet high, and the top is 3½ feet broad (Plate II., fig. 2). The soil is composed of dust blown from the roads, held in the meshes consisting of the root-fibres of the grasses and other plants. This soil is enriched in course of time by the rotted remains of the plants present, and although not to be despised in a wet season, it is subject to thorough desiccation in a hot, dry one.

The adaptation of the Crow Garlic to its home conditions is specially striking. Its bulb is prepared to withstand long periods of drought, not only by virtue of its fleshy internal structure, but also by means of its thick protective fibrous coats. Examined in the spring time, the coats formed from the narrowed portions of the leaf-bases reach from 2 to 2⅓ inches up from the base of the bulb, and above these to the height of 3 to 6 inches the stem is covered by the transparent sheaths of the younger leaves, the blades of which are withered in many cases. The leaves also proclaim the adaptation of the species to drought resistance, being narrow and nearly cylindrical. At this period also the roots are produced in great numbers, and are very slender. The flattened remains of the old bulb are then very easily separable from the base of the new bulb. Bulbils occur on the sides of the parent bulb.

But the most surprising feature of its economy has yet to be mentioned. It bears tall flower-stalks, and one would naturally expect to see flowers where they occur in other onions. The spherical head is produced, but almost invariably no flowers, their place being taken by a dense mass of bulbils no larger than grains of wheat (Plate II., fig. 7). In some parts of the country where this plant grows, a few flowers are produced by it, but here bulbils only, as far as I have observed, unless one takes into account a few rudimentary flowers seen in three or four per cent of the heads. Small bristle-like leaves are produced from many of the bulbils, shortly after they are freed from the spathe, especially those at the apex of the head.

It is easy to see that the bulbils, being fleshy and provided in themselves with a store of water, are much more likely to survive and perpetuate the species in such a place as the top of this wall than seeds would, and there seems to be no escape from the inference that the substitution of bulbils for seeds has come about gradually, through the survival of plants having a tendency to bear bulbils rather than seeds. This plant thus affords a fine example of what nowadays is called an ecological problem.

In 1907, a very wet season, the plants grew unusually strong on the wall, many being 2 feet high and bearing greatly enlarged single heads, several with two sub-cylindrical masses and a few with three almost equal in size to the normal single head produced in a drier season. The usual height is about 18 inches.

Many years ago I took a number of specimens from the wall in the month of June, and planted them in the rich, deep soil of the University Botanic Garden, in the hope of inducing some return to a more normal condition. They made the usual growth during that summer, but, in the following season, instead of producing flowers, they

larly the Artillery Plant, on account of the miniature bombardment it executes with its pollen.

Another plant growing in the crevices is the **Wall-rue Spleenwort** (*Asplenium Ruta-muraria*), one of our native ferns (Plate II., fig. 9). It is usual to associate ferns with bosky moist habitats: here we have one which occupies a home of an entirely different nature. The roots are found squeezing themselves into the merest chink between the stones. The leaves[1] of young specimens are reniform; later they are branched, and bear deltoid pinnæ. The developing leaves are thickly covered with hairs which die and fall off when maturity is reached. A hairy covering is a very familiar feature in plants which have to undergo conditions of drought. Here it is needed to protect the delicate young leaves.

This singular fern is found growing in the full blaze of the sunlight where the stones become heated to a high temperature. It seems impossible that in summer, for days together, it can have even a trace of moisture to refresh its roots. The general texture of the leaves is somewhat leathery, and the stalks are distinctly wiry. Close inspection, however, shows that there is a considerable degree of succulence in the fresh foliage. In spring a crowd of leaves of the freshest green is put forth. At first these leaves form a nest, but gradually they uncoil themselves and assume the spreading, branching form.

The mature leaves bear an enormous number of spore-cases or sporangia, easily seen in patches occupying almost the entire under surface of the pinnæ. The hand-lens discloses their general form. They are seen to be delicate sacs, which rupture when ripe, consequent on the pull then exerted by a median elastic band, when the spores are flung forth. Each sorus or group of spore-cases is at first protected by a membranous covering called the

[1] Often designated fronds.

indusium; and the presence or absence of this, as well as the position and form of the sori, enable the botanist to classify the ferns into groups.

Ferns differ from flowering-plants in being propagated by microscopic bodies, the spores, which are entirely different from seeds. They are individually invisible to the naked eye, and can be borne along by the slightest breeze and lodged in the depths of very narrow chinks. Moisture is necessary to enable them to pass through the early phase of their existence, called the prothallus, which appears in the form of a minute flattened scale bearing the reproductive apparatus on its under side.

Another plant thoroughly adapted to thrive in extremely dry situations is found flourishing on the top of the wall—the **Biting Stonecrop** or **Wall-pepper** (*Sedum acre*). The reduction in the size of the leaves, and their great succulence, are very characteristic features. The acridity of the leaves is notorious. The flowers are bright yellow, and considerable patches of them are to be seen ornamenting the wall at midsummer.

At one place a number of plants of the **Common Wormwood** (*Artemisia Absinthium*) find a home on the top of the wall. This plant is characterised by the finely tomentose covering of both the upper and under sides of its leaves, as well as its stem and branches, and by its strong scent. It may be mentioned that the powerfully spirituous liquor, absinth, is distilled from this plant. Another species, the **Mugwort** (*Artemisia vulgaris*), is much more common in the neighbourhood. It is less tomentose. A few strong plants of it decorated the exterior of the West Port for several years. They, and a considerable number of plants hidden in the inner recesses of the parapets, were removed a short time ago when pointing was carried out. The Artemisias are well adapted for flourishing in arid places. A large part of the vegetation one sees in such places as the desert round the Great Salt Lake, in Utah, is composed of them, and their silver-grey leaves form part of the general colour-scheme of the parched and powdery landscape.

Among the grasses which grow on the top of the wall one may be specially referred to—*Koeleria cristata.* It bears a close silvery ear, not without resemblance to the Woolly Soft Grass or Yorkshire Fog, that far too common pest of pasture land. It does not seem to have been outstanding enough to receive a trivial or common name. This grass occurs also at both the East and West Bents.

As is to be expected in an ancient city, Ivy is much in evidence. Many of the ruins are clothed with it. Several of the towers in the Abbey Wall are adorned with the Common Ivy, and the plants seem to be of very respectable antiquity.

The **Ivy** clings closely to the wall by means of immense numbers of roots which appear on the young shoots as occasion requires. They arise on the side of the branch which is pressed against the wall, and are quite distinct in their function from the roots which spread in all directions in the ground,—that is to say, they are clinging organs, not sustentative ones. When the Ivy shoot is climbing it is two-sided, the leaves all directed outwards and the aerial roots all backwards, and no flowers are produced on such a shoot. Growth continues, and, in time, shoots have to find room unsupported in space (Plate II., fig. 4). A remarkable change in growth ensues, the shoots become strong and self-supporting, no more aerial roots are produced, and the leaves arrange themselves regularly in all directions. The flowers appear on these free branches. They are quite destitute of attractive coloration, but produce abundant nectar from the large glands which cap the undeveloped seed-vessels. The fruits are small, dark berries.

A nearly allied relative of the Ivy, sometimes popularly confused with the castor-oil plant on account of the general similarity of the leaves, is *Fatsia (Aralia) japonica.* This interesting Japanese shrub, although commonly grown indoors as a room plant, proves hardy with us when planted out, and is often seen bearing its large trusses of ivy-like flowers in the open.

Great changes have been made in the grounds of St. Leonards since they were acquired by the School. As already mentioned, the **Mill Lade** ran as an open streamlet across the grounds, its position being traceable now by the man-holes in the walks. The first part of it to be covered was that crossing the Bishop's Hall grounds. This was done soon after the College Hall (now Bishop's Hall) was built. Many years after that, the part running through the old Provost's or St. Leonards Garden was covered in. Afterwards, when the Sanatorium was built where the Abbey Mill stood, the dam was converted into a quiet retreat with lawn and hedges, protection from the north being effected by the wall which formed the north edge of the dam.

The whole of the turf in the large playground was lifted and, after levelling, relaid. The lower part in the hollow where the drive runs up from the Abbey Wall gateway was intersected by old walls, and the ground was very uneven and undulating. The hard courts in the part of the grounds nearest the sea overlie fine deep garden soil. When a garden was there, antique tobacco-pipes were found in numbers.

In course of levelling the ground at the Sanatorium, and also at the terrace which runs along the slope at the eastern edge of the large field, a great accumulation of **incinerated material** was cut into. No objects of antiquarian interest were found in it. The material seemed to have been straw or cloth, or some such substance as could be thoroughly reduced by fire.

In relaying the old turf, the absence of stones in the upper layer a spade-depth or more was observed. Their absence is due to the earthworms which, as Darwin has shown, by adding soil to the surface, cause the stones in course of years to sink.

In the lower portion of the grounds nearest the sea, the black soil overlies a large deposit of gravel and sea sand, and this in its turn lies on clay. The section made when the gasholder was constructed in 1903 (Plate II., fig. 3) seemed to show that the estuary of the stream, now the Kinness Burn, had been flanked by low sandhills. The sand extends upwards some distance in the direction of the Burgh School. Beneath the sand, the clay is to all appearance alluvial, but at lower levels it is **boulder clay.** A block in my possession, which I picked out of the clay, sixteen feet beneath the surface, is well covered with the characteristic scratches. The boulder clay passes under the harbour, and is exposed on the East Sands (see Plate X., fig. 3).

The subsoil of the greater part of St. Leonards grounds is probably brick clay. When the drain leading from the new Science Laboratories to the Abbey Walk was made recently, the foundation of the Abbey Wall was seen to go down only two feet beneath the surface of the pathway, and it rested on the clay. The ground on the inside is about three feet higher than the walk at the point in question. The clayey bottom of the old Provost's Garden led to its being water-logged occasionally, and many years ago, after an exceptionally long period of rainy weather the water rose and remained for a time, so chilling the roots of the fruit trees—of which there were many fine ones—that they were never quite so flourishing afterwards.

Before leaving St. Leonards it may be of service to mention a few of the decorative shrubs growing in the neighbourhood of the Sanatorium. The following are noteworthy on account of their ability to withstand the sea breezes: *Griselinia littoralis* and *Olearia Hastii* (New Zealand), *Skimmia japonica* and *Osmanthus Aquifolium* var. *ilicifolius* (Japan), and the Common Tamarisk and Sea Buckthorn.

Other shrubs include *Berberis Aquifolium* (North America), *Berberis stenophylla* (hybrid), *Spiræa Douglasii* (North-west America), *Spiræa japonica* (Japan), *Prunus cerasifera* var. *atropurpurea*, *Cytisus albus* (Spain), *Deutzia crenata* (Japan), *Aucuba japonica* (Japan), *Hypericum calycinum* (South-east Europe), *Viburnum Opulus* (Guelder Rose — Britain), *Cornus sanguineus* (Common Dogwood—England).

Chapter III.

The West Sands.

THE West Sands form an uninterrupted level stretch extending from the Swilcan Burn to the estuary of the Eden, a distance of about two miles. At low tide the width of the shore exposed is from four to five hundred yards. The sand is firm and forms a pleasant promenade, until the "Outhead" is reached, where a part of it is unpleasantly soft. Certain sandy places among the rocks at the mouth of the Swilcan Burn have from time immemorial been held to be dangerous, on account of supposed quicksands there, but it would seem that the danger rather lies in the occurrence of holes which deepen suddenly. Although the Swilcan now finds its way to the sea across the level sand, the trough filled with sand and gravel beneath is of great depth.

The formation of the Bruce Embankment has altered the appearance of the foreshore very materially. Previous to that the sea had an uninterrupted course from the Witch Lake to the mouth of the Swilcan. By placing obsolete fishing-boats filled with stones across the lake at the west corner of the little bay that used to be called the "C" (pronounced by the older generation "say"), to the massive white sandstone rock called the Doo Craig, the late Mr. George Bruce initiated a movement for the reclamation of that part of the shore. Great quantities of

PLATE III.

FIG.

1. Marine *débris* on the West Sands.
2. Sea-snail (*Natica catena*).
3. Sea-Mat (*Flustra foliacea*).
4. Egg-capsules of *Fusus*.
5. *Pholas crispata*—inner side.
6. Do.—outer side.
7. *Pholas candida*.
8. Sea Mouse (*Aphrodite aculeata*).
9. Iceland Cyprina (*Cyprina islandica*).
10. Thick Trough Shell (*Mactra solida*).
11. Striped Venus (*Venus gallina*).
12. Heart-urchin—oral and aboral aspects.
13. Tubes of *Terebella (Lanice) conchilega*.
14. Mermaid's Glove (*Chalina oculata*).
15. Common Gaper Shell (*Mya arenaria*).
16. Acorn-shells or Barnacles.

LATE III.

city refuse have been carted there, and a concrete protecting-wall has been built on the north side. The general effect does not commend itself to all. The concrete wall is a feature difficult to tolerate. There are those who wish to see St. Andrews and its environs changed as little as possible. It is nothing if not an "ancient city," and concrete was not used by the builders of the Cathedral or the Colleges. It seems inevitable that modernity must annihilate much that is of inestimable worth, but it is surely possible to secure a reasonable share of the advantages of present-day progress without so much sacrifice of the old-time tone that lends to St. Andrews its greatest charm. A preposterous proposal has occasionally been mooted to construct a promenade, after the pattern familiar to *habitués* of the gay English and other seaside resorts, as an extension of the Bruce Embankment along the West Sands. It is hardly conceivable that any lover of St. Andrews, whether native or not, would support a proposal of this kind. It is to be sincerely hoped that the time is not far distant when the grievous eyesore which the western face of the Bruce Embankment perpetually presents will be changed so as to be more in accordance with the attractive surroundings. In the meantime the foreshore there, especially after a storm, is littered with objects which give an unpleasant impression to the naturalist as he sets out to explore the Sands.

There is very much at the West Sands to interest the zoologist at all seasons, but it is after heavy storms that the richest treasures are cast ashore. At almost any time, however, the representatives of the fauna of the Bay about to be described may be found.

The illustration (Plate III., fig. 1) is from a photograph taken on 2nd January 1908. A storm had covered the beach with great wreaths of marine *débris*, representing hundreds of tons, chiefly composed of the tubes of an annelid (Fig. 13), to be described below, but including also large numbers of heart urchins (Fig. 12), and a great variety of shells. The shells, when cast ashore, often contain the living animal within, and an opportunity is thus afforded of studying their structure and thereby in a measure understanding their habits. Although, in many cases, the action of the waves abrades and damages the shells, perfect or almost perfect specimens can be readily picked up. The sea-birds find the shore for a considerable time a rich field for food. In this connection Dr. Hay Fleming tells me of an incident he observed at the West Sands, when exercising on horseback there. He noticed at a distance a sea-bird descend with great rapidity and strike a shell lying on the hard sand, the impact being so violent as to resound not unlike the report of a pistol. As he rode up quickly the bird flew away, and he was surprised to find that it had broken a large, thick "Daikie" shell into several pieces without sustaining any injury to itself.

Notes were taken at the Sands on 20th March 1909, after very stormy weather. The chief item of interest was the great number of the Thick Trough Shell (*Mactra solida*) (Fig. 10) cast ashore. They lay in many places as thickly as one finds heart urchins strewn at other times. Being so solid and white, they formed a striking sight. Many of them had the animal still fresh within.

When the weather is dry and the wind westerly, the sand above high-water mark races seaward in low skimming flight and, falling in a fine shower, hides the shells and seaweeds. By this means, or by the action of the sea itself, the strand at times is relatively very poor in respect of specimens. Such, for instance, was the case in the early part of the month of August 1909, when the Nature Study Excursion Class visited the West Sands, the shells left uncovered being then very scarce. Exposure to the sun and air bleaches the shells, and destroys the epidermis when present.

The shells found on the shore are of two distinct types, the univalve and the bivalve. Amongst the univalves the most likely to attract attention is the **Common Whelk** (*Buccinum undatum*), called locally the Dog Whelk. It is white or creamy, and on an average 4 inches in length. It consists of six or seven whorls which gradually increase in girth from the pointed apex to the wide mouth, and is finely sculptured with undulations, grooves, and lines. If the specimen examined has been cast ashore with its living inhabitant inside, the mouth will be found to be closed with a flat horny disc, the operculum. If opportunity is given, the creature will protrude a part of its body, the operculum being then seen to be fixed firmly where it can be thrust out of the way when locomotion or feeding is in progress. In this, as in other shell-bearing molluscs, the shell is a covering secreted for the purpose of protecting the soft tissues of the body. The Common Whelk lives well out in the Bay on rocky ground. If the fishing lines have to be left for a day or longer on account of stormy weather, it is common to find that the fish hooked are devoured by the Whelks, the skin and the bones being alone left.

Another shell bearing a close resemblance to that just described, but of much less common occurrence, is to be met with. It is easily distinguished from the foregoing by being more elongated and considerably narrower. Its association with colder regions is indicated by its name, the **Iceland Spindle** (*Fusus gracilis* or *F. islandicus*).

Yet another shell like the Buccinum, but of considerably larger size, indeed the largest of its kind, is by no means rare on the West Sands. It is known as the Roaring Shell or **Buckie,** and, scientifically, as *Fusus antiquus* or *Neptunea antiqua*. This very elegant shell is much smoother than the Whelk. It is sometimes used to form the bowl of a lamp, being hung so that its capacious cavity holds the oil, while the wick lies in the groove or siphonal canal at the edge of the mouth.

A brief search on the shore will almost certainly lead to the finding of an elastic mass popularly mistaken for a sponge. It bears a general resemblance to a rough-meshed bath-sponge. It is seen to be composed of lobules of very tough parchment-like substance. When fresh the contents of the lobules can be studied. In early stages they consist of eggs, and later of young univalves. The mass illustrated in Plate III., fig. 4, is probably the egg-capsules of the species just described. Those of the Common Whelk (*Buccinum*) are of most frequent occurrence. Such egg-masses are attached to rocks, stones, shells and other objects, from which they are torn off by storms.

Numerous examples of a small shell of the same pattern as the above are met with—the **White Whelk** of the local fishermen, the **Dog Periwinkle** (*Purpura lapillus*) of others. The shell measures 1 to 1½ inch, and is particularly solid. This mollusc will be referred to again (see Plate VI., fig. 4).

Examples of the very familiar **Periwinkle** (*Littorina littorea*) and its squat relative, *L. littoralis* or *L. obtusata*, are plentiful.

A very beautiful shell (Plate III., fig. 2), approaching the spherical in form, and of delicate pink colour, with radiate brown markings in the hollows where the whorls meet, is quite common. It is named the **Sea-snail** (*Natica catena*). Its egg-mass bears no resemblance to that of *Fusus* or *Buccinum*. It is to be found occasionally on the beach. When dried it consists to all appearance of a mass of sand-grains cemented together to form a thin band which is bent into a hoof-shaped ring.

set up by means of microscopic cilia kept in active motion. It is thus that the food and oxygenated water are supplied, and effete products ejected. A small hole at the surface of the mud, when the tide is out, indicates the position of the mollusc. The presence of the siphon is a distinctive character of a large group of bivalves.

The gap at the wider end has reference to the protrusion downwards of a massive fleshy organ called the foot, which is used in making room for the mollusc in the mud in which it lives.

The meaning of the lines etched in the interior of the shells can now be understood. The bay marks the position of the siphon, and the line parallel to the edge shows where the mantle is attached. The two scars are the seats respectively of the anterior and posterior muscles which close the valves.

In determining the right from the left valve, it is in the first place essential to decide which is the anterior and which the posterior end of the shell-fish. In the case of Mya it has to be remembered that it is morphologically upside-down when it is found alive in the mud, the siphon projecting from the posterior end, and the foot from the anterior. When inspecting the shell, it is held with the hinge towards the observer and the siphon-bearing end directed downwards. Held in this position, the tooth-like projection referred to above will be seen to belong to the left valve.

Another species of common occurrence is the **Blunt Gaper** (*Mya truncata*), so called on account of the truncated or squared shape of the siphon-bearing end. Malformation of the valves is of very common occurrence in this species.

A shell of an entirely different form is found almost everywhere on the beach. It consists of two straight valves 1 inch wide and at most 8 inches long. The ends are cut almost straight across, and when the two valves are approximated they form a tube quite open at both extremities. A single valve bears some resemblance to a hollow-ground razor, hence the name Razor Shell given to this mollusc. For the sake of distinction it has been called the **Pod Razor.** It is known to science as *Solen siliqua*. A yellowish membrane, not unlike a thick coat of varnish, forms a covering to the exterior of the valves, while the interior presents a beautiful porcelain-like polish. The hinge is terminal, and consists of two short solid teeth in the left valve with a notch between them into which a single tooth borne by the right valve passes.

As in the case of the Gapers, the Razor Shell possesses a siphon and a foot. The foot is a powerful organ, and is of much service to the creature in enabling it to retreat with great rapidity into its burrow when threatened with danger. It is possible to dig the living Razor Shell out of the sand by approaching cautiously and using the spade promptly.

The shells of another species, the **Sabre Razor** (*Solen ensis*), are plentiful. They are characterised by being curved, not straight, and they do not attain the same dimensions as the Pod Razor.

Bivalves representing a type distinct from those already studied are to be found. The most conspicuous of them is a large brown shell strewn in hundreds on the strand after storms. It is the **Iceland Cyprina,** locally called the "Daikie," and known to science as *Cyprina islandica* (Plate III., fig. 9). This shell measures 4 inches in diameter, and is nearly circular in outline. The epidermis, as the outer thin skin coating the limy shell is called, is olive brown. The valves are very stout. When pressed together they form a completely closed casket. When the inmate desires to refresh itself it requires to separate its valves and protrude its siphon, which is an extremely short one. In the illustration the two scar-like pits where the muscles employed in opening and closing the valves are inserted are well shown, and also the line of attachment of the edge of the mantle (the pallial line).

Another siphonate shell-fish which can close its valves completely is the **Thick Trough Shell** (*Mactra solida*) (Plate III., fig. 10). As already mentioned, it can always be found on the beach. The common name has been chosen because of the resemblance of the valve to a kneading-trough. The foot when retracted is massive and compressed. It can, however, be greatly extended when in use as an organ of locomotion.

Another shell of the same genus, the **Radiated Trough Shell** (*Mactra stultorum*), is also extremely plentiful. It is at once distinguished from its relative by the comparative thinness of the shell, and the presence of pale rays which traverse the exterior of the valves from the hinge to the margin. In one specimen picked up a highly polished, flattened black mass of pearl had invaded a corner of the interior. In course of time, when kept in the cabinet, the black tinge disappeared.

A very large shell presenting a considerable resemblance to, and commonly larger than, *Mya arenaria*, but more nearly related to *Mactra*, is called the **Oval Otter Shell** (*Lutraria elliptica*). Its colour externally when fresh is olive brown. Gaps between the approximated valves exist as in Mya, and for the same purpose, the Otter Shell also inhabiting the oozy mud. One distinguishing character is to be noted in the structure of the hinge, there being a spoon-shaped projection in each valve and a tooth in the right one which fits into a pit in the left.

A comparatively small shell of triangular or heart-shaped outline, and etched deeply with ripple-like concentric ridges, is to be met with at all times (Plate III., fig. 11). It is named the **Striped Venus** (*Venus gallina*). A common length is 1 inch. The ground colour is usually reddish-grey, and there is further ornamentation by a few pale bands which radiate from the beak to the margin.

A species of common occurrence very closely related to the shell last described is the **Smooth Artemis** (*Artemis lincta*). This shell is of the same general form as Cyprina, but quite small, being seldom more than 1½ inch in diameter. Its colour is ivory white, shading into orange at the beaks. The exterior is engraved with extremely delicate and closely-set grooves and ridges.

One of the smaller shells is the **Common Wedge Shell** (*Donax vittatus* or *D. anatinus*). The specimen chosen for description was one and five-sixteenth inch in length and eleven-sixteenth inch in breadth. The shape is elongated and wedge-like. The exterior is covered with a glossy transparent epidermis, through which concentric lilac banding and two pale diverging rays are clearly visible. Extremely fine sculptured lines, requiring the use of the lens to see them distinctly, radiate across the valves, and the ventral margin is crenated so as to resemble the milled edge of a coin. The milling is sufficient in itself to distinguish this shell. The interior is usually extensively tinted with a beautiful violet.

An even more decidedly elongated shell is the **Striped Sunset Shell** (*Psammobia ferroensis*). It is twice as long as broad, the longest example being two inches. The anterior extremity is rounded, the posterior angulated and pointed. The valves are much flattened, and gape slightly at each end. When, by removal of the dull-toned epidermis, the surface of the shell is exposed, it is seen to be prettily marked with alternate rays of rich pink and white, reminding one not a little of sunset effects.

Great numbers of the **Common** or **Edible Cockle** (*Cardium edule*) are cast ashore. The cockle is easily distinguished by the conspicuous ridges and furrows which run from the beak in a radiate manner to the edge of the valves. These ridges and furrows are so disposed alternately that those of the opposite valves interlock and fit into each other perfectly when the valves are pressed together.

Besides the Common Cockle it is usually possible to pick up specimens of a much larger and finer species on the sands, viz., *Cardium echinatum.* It is certainly one of the most beautiful of our native species. It is a roomy, rounded, slightly heart-shaped shell, with exceedingly well-defined ridges radiating in beautiful curves from the beaks, and bearing on their flattened tops single median rows of short, white spines. The interlocking of the opposing parts of the elevated ridges and the sunken sulci is singularly perfect, permitting of absolutely no lateral movement between the valves when they are closely shut.

We must not omit to mention two remarkable shells found on the sands, especially after severe storms. They are almost always found singly, and are accordingly apt to mislead the beginner. One of them is the shell of *Pholas crispata* (Plate III., figs. 5, 6), the other of *Pholas candida* (Fig. 7). The former is much the more plentiful. *Pholas*, popularly termed the Piddock, is a very peculiar shell-fish which lives in the holes it bores in the shale and sometimes in much harder rocks. Reference will be made to its habits in a later chapter. It so far resembles the bivalves we have studied in being siphonate. A distinctive feature is the presence of a long, flat, curved hook of shell projecting from the hinge region into the interior, faintly shown in fig. 5.

The shell of *Pholas candida* is a beautiful object, not only on account of its wing-like shape and its delicate sculpturing, but also because of its fragile and semi-pellucid character.

The above bivalves are all characterised by possessing the organ termed the siphon. That organ varies in length and the degree of union of the two tubes comprising it in the different genera and species described.

Representatives of the Asiphonia—those without a siphon—include the Scallop (*Pecten opercularis*), the Common Mussel (*Mytilus edulis*), and the Horse Mussel (*Modiola modiolus*).

The notes given above are necessarily conchological rather than anatomical, but naturalists who have leisure can find a considerable number of the species alive by digging for them in the sand and mud towards the Eden at low-water mark, or by dredging a short distance from the shore.

The shells enumerated are the commoner species. The enthusiastic collector can easily add greatly to the number. Professor M'Intosh, in his finely illustrated work, 'Marine Invertebrates and Fishes of St. Andrews,' names over fifty univalves (Gastropods) and over seventy bivalves (Lamellibranchs).

Leaving the Mollusca, we find many representatives of other groups of the Animal Kingdom. In our search for shells we have no doubt been crunching under foot many specimens of a delicate heart-shaped casket which litters the shore between tide-marks. When lifted, a specimen reminds one of an egg blown and ready for the cabinet. Very casual examination shows that our specimen is flattened, and on the side which appears to be the base there is a sub-central aperture, suggesting the presence of a mouth. The rounded back is adorned with a geometric design of dots which radiate in five tracts asymmetrically from a point.

In some cases we are fortunate in finding evidence that the dots are spots to which small spines had been attached. This fact, and the presence of the five areas, lead us to connect our specimen with the Cross-fish or Star-fish and the Sea-urchin or Egg-urchin, both of which, but more especially the former, are to be met with on the beach. Our specimen is the **Heart-urchin** (*Spatangus purpureus*) (Plate III., fig. 12). When dredged for, a little beyond low-water mark, it is taken alive, and is then seen to be a greyish object, thickly coated with spines, and possessed of the curious, protrusible, movable tubes which constitute the "feet," so easily observable in the Cross-fish.

The Heart-urchin differs from the Egg-urchin in being asymmetrical, and its shell is much more delicate. The Cross-fish differs from both in forming no box. All these, and many other most interesting forms, belong to the same family—that appropriately named the Echinodermata.

After storms one is almost certain to find rather shapeless, white, fleshy masses, each often about the size of, and with some resemblance to, a closed fist. Sometimes an example roughly resembles an open hand, hence the common name—**Dead Men's Fingers.** The scientific name is *Alcyonium digitatum.* The masses, as they lie on the beach, show no signs of life, and unless one were to see the "Fingers" in an undisturbed state, attached to the rock where they live, and when the water covers them, it would be very difficult to imagine what they were. In the rock pools, at specially low tides, one sees occasional examples, and there they wear a much more attractive appearance than might be imagined possible when they are seen elsewhere. From out of the numerous facets which form the exterior of the mass, delicate tubular zooids emerge, and the dead-looking surface becomes alive with miniature sea anemones. These

beginner imagines that they are sea-weeds. They lack the distinct coloration of sea-weeds, and inspection shows that they are horny. Some of them are delicate and feathery, for example *Sertularia* and *Obelia;* others are more substantial, the best example being the **Sea-Mat** (*Flustra foliacea*) (Plate III., fig. 3). To appreciate the structure of the zoophytes, one must get fresh specimens and have recourse to the microscope.

The material forming the translucent framework of *Sertularia* is described as chitinous. When the specimens are driven on shore, little else is left than the skeleton. The microscope shows that in *Sertularia* there are two rows of minute sessile vases. In *Obelia*, on the other hand, the vases are borne singly on stalks. Occasionally compact balls, several inches in diameter, composed of the interlaced fibres of *Obelia*, are to be found on the beach. They are formed by being rolled about by wave-action.

The organisation of the Hydroid Zoophytes, including *Sertularia* and *Obelia*, is of a lowly order at best. It is otherwise with the individuals which collectively form the colonies of the Bryozoan or Polyzoan Zoophytes, the group to which the Sea-Mat belongs. They possess organs which, in point of complexity and advancement, entitle them to occupy a much higher place in the animal kingdom. Systematists, in recognition of the affinities of the Polyzoa with the worms on the one hand and the molluscs on the other, have assigned them a place intermediate between these two groups.

Another object (Plate III., fig. 14), conforming in no way to our ordinary conception of an animal type, is often met with. It is irregularly branched, and has apparently been fixed to a rock by its narrow base. The texture can best be described as spongy, and this gives a clue to its identity. It is in fact one of our native sponges, *Chalina oculata*, called by some the **Mermaid's Glove.**

We shall have occasion later to make reference to the structure of other sponges which can be seen at home amongst the rocks. *Chalina* lives in deep water, and is characterised by being formed of fibres of the same material as the bath-sponge is. The tissue, however, is largely occupied with silicious spicules. The specimen figured is seen to be pierced by numerous dark bristles, which an examination of the Sea Mouse will help us to identify.

The **Sea Mouse** (*Aphrodite aculeata*) (Plate III., fig. 8) is often one of the unfortunates which have to yield to the onslaughts of the waves and are flung on shore. When lying on the sand it looks in the distance not unlike a drowned mouse. Close inspection reveals beauties which the mouse cannot boast of. Its sides are clothed with hairs which vie with the rainbow in brilliancy of prismatic coloration. Besides the shiny hairs, there are numerous stout bristles which project from its sides and "feet," and it would seem from the pincushion-like condition of *Chalina* that these must be apt to pierce other creatures when they come in contact with them. The Sea Mouse is one of the polychætous Annelids, a group to which the lob-worm of our sandy shores and many other sea-worms belong.

The Annelid (*Terebella* or *Lanice conchilega*) which constructs the tubes cast ashore in masses also belongs to this class. The tubes (Plate III., fig. 13) are formed by a glutinous secretion from the animal's body. This becomes tough and elastic, and on the outside are firmly attached a great number of sand grains and minute pieces of broken shells. The living creatures can be found in their tubes in the sand in the region near low-water mark.

The last object to be chosen for observation consists of a drifted piece of twig covered with a crowd of small shells (Plate III., fig. 16). The same shells can be seen covering a great variety of bodies both animate and inanimate. Many shell-fish are seen to be thickly studded with them, and they do not despise the back of the crab. The rocks in many places are densely carpeted with them. They seem to the tyro to have some relationship with the Limpet, but the slightest inspection shows that the shell, instead of being composed of one imperforate valve, is built up of several plates, and an aperture, closed by four small closely-fitting pieces, is present at the apex. They are **Acorn-shells** or Barnacles (*Balanus balanoides*).

PLATE IV.

FIG.

1. Sand Dunes at the West Sands.
2. Marram (*Ammophila (Psamma) arenaria*).
3. Sea Lyme-grass (*Elymus arenarius*).
4. Ergot, bearing stromata.
5. English Catchfly (*Silene anglica*).
6. Fine-leaved Sheep's Fescue.
7. Rest-harrow or Wild Liquorice (*Ononis arvensis*).
8. *Ustilago hypodytes*, parasitic on Sea Lyme-grass.
9. Fine-leaved Heath (*Erica cinerea*).
10. Lesser Meadow-Rue (*Thalictrum minus*).
11. Moonwort (*Botrychium Lunaria*).
12. Whitlow Grass on the Links.

TE IV.

It may be recalled that, according to a plan of the Links published in 1836, the Course between the Club House and the Swilcan Burn was only about 75 yards wide. In Roger's 'History of St. Andrews' (1849) it is stated that, at the instance of Provost Playfair, an embankment was made along the east side where it was exposed to the action of the waves, and earth being filled in and grass seed sown, several acres were thus added to the Course. By 1854 the width had been increased to 100 yards, and it is now 180 yards.

The most notable feature of the topography of the Links is the range of **sand-hills** or **dunes** which forms the eastern boundary (Plate IV., fig. 1), and was up till a few years ago the barrier which prevented the sea from making inroads on the Links. But for the presence of the hills it is certain that the sea would have had very little trouble in washing away large slices when high tides were in league with easterly storms. Quite lately, breaks in the sand-hills allowed the waves to reach the surface of the Links here and there. The formation of such dunes is exemplified in many parts of the coast. They owe their existence almost entirely to the presence of a native grass, the **Marram** or **Sea Mat-grass,** locally called the Bent Grass (*Ammophila (Psamma) arenaria*) (Plate IV., fig. 2). This grass is thoroughly adapted for growing in loose and blowing sand. Neither burial in the sand, almost to the tips of the leaves, nor exposure of a large part of the root-system incommodes it seriously. Its stout rhizomes and fibrous roots interlace to form a network which binds the sand very effectively. From the underground parts leaves of a remarkable character arise into the air—long, narrow, stiff, polished, and pointed. When luxuriant the leaves are almost flat, but usually they are infolded lengthwise. By this involution the transpiring organs—the stomata—which are situated on the underside of the leaf are protected from the action of air-currents and drought. The sharpness and smoothness will aid the leaf in pushing up through the sand. The roots reach down to moisture, which is always present in any considerable heap of sand. The surface of the sand shifts with the wind, and long-continued gales have the effect of moving very considerable masses and actually changing the shape and position of the hills. It is very probable that the chief undulations of the Links have been formed by the movement of the sand by the wind and the fixing action of the Marram and other plants.

The sand-hills certainly owe their existence to the result of a struggle in which the sea, the wind, and the grass took an active part, the sand being the passive agent. The Marram flourishes best in the near neighbourhood of the sea, and its tendency is to seek fresh fields by encroaching on the unoccupied shore. The sea sand when dried by the sun and wind, and blown amongst the tufts of the grass, is caught and caused to form little heaps about the growing plants. This accession gives new life to the plants, and they grow stronger and put forth offshoots, with the result that more and more sand is caught and kept. The sea, especially in severe storms, dashes over the small hills, and cuts out perpendicular breaches in the larger ones. The soaking with sea water seems to refresh the tufts which had been submerged, and the *débris*, made up of seaweeds and the remains of sea creatures, acts as a fertiliser. When the storm abates, the sheer faces cut out of the larger sand-dunes become obliterated before long, it may be at the expense of the lowering of the height by subsidence and collapse. The sand eroded by the waves has not been lost—it is spread on the shore, and is available for further hill-building. The Marram Grass is in triumphal possession, and although, as is often the case, the hills are rolled landward rather than seaward, they may go on increasing in bulk. A time may come when the warfare ceases and the gathered sand remains at rest. Other grasses, such as cannot flourish in shifting or hot sand, now find a place to grow, and a mat worthy of the name of turf is formed. The dead parts of the plants contribute organic matter, and by-and-by a somewhat peaty soil is produced, capable of supporting a different race of plants, but still turf-forming ones. In the old-established but natural sward this peaty soil extends a few inches, at most 6 to 9, downwards.

Towards the estuary of the Eden the bunkers reveal the fact that the cockle beds of the river had extended well over the ground occupied by the north portion of the Links. Probably the Marram was responsible in great part for the reclamation there.

Laws have been enacted to enforce the preservation of Marram on our coasts. It is said that the thoughtless destruction of it was the cause of the advance of the sand which overwhelmed a large tract of land near the Moray Firth. In Holland stringent laws exist to prevent the grass being cut.

In a somewhat recently-coined terminology the Marram and similar plants are designated xerophytic. By a **xerophyte** is literally meant a plant adapted to grow in dry soil. Xerophytic plants are understood to have been driven to, or to have sought for themselves, dry soils. They have at all events become suited to live, and even to thrive, there. The conditions of their existence are peculiar. An outstanding feature in their environment is the occurrence of protracted periods of drought, and preparations, so to speak, have to be made to bear the brunt of it. We cannot very well escape believing—we are certainly near the truth in assuming—that the progenitors of those plants have become adapted little by little to withstand, and even enjoy, such treatment, and in the process have developed peculiarities of structure and habits of life which are now found intimately associated with the conditions in question. The characters of xerophytes as a group are such as these: the reduction of the area of transpiring surfaces, the augmentation of tough tissues, the elongation of the palisade cells of the leaf, the thickening of the cuticle, the increase of the number of air-containing hairs, and the sinking of the stomata. These features have reference more or less to the conservation of water in the plant, or protection from excessive loss of it. How, in the response to the environmental conditions in which the plant finds itself, the modifications referred to arise and are fashioned, is a tantalisingly inscrutable matter, and one which affords a fine field for ingenious speculation and stimulating research. The object of the various modifications is less difficult to discern. The so-called xerophytic characters are diagnostic of many plants growing not only in sandy places like the dunes, but in deserts, peat-mosses, and very cold regions.

The sand-dunes are one of the scenic features of St. Andrews. Generations of citizens have looked out from the town and found their rugged outlines to be highly picturesque. No one with a trace of feeling for art would for a moment wish to have them rounded off and smoothed. What one prays for is to see them left as long as misplaced utilitarianism can exercise its energy elsewhere. Even to plant anything on them is little short of vandalism in the naturalist's eyes. Their scientific value is great, because they are grand examples of natural dunes, with the vegetation that helped to form them still there.

This plea for the preservation of the sand-dunes need not lose in force although a good deal of their original significance has been lost through another cause, namely, the changes brought about on their seaward side by the spread of the **Sea Lyme-grass** (*Elymus arenarius*). This grass (Plate IV., fig. 3) is held to be a native of Britain. It is now impossible to say when it first appeared on the shore at St. Andrews. If my recollection serves me aright, Mr. C. Howie once told me that the Lyme-grass, prior to his introduction of it at the Links, grew at Dennis Work, and that he imagined someone must have planted it there. He mentioned that it grew also at Kinkell Cave. A considerable patch of it flourished in the sandy beach at the cave until comparatively recent times, but none of it is there now. Small patches of it still grow amongst the rocks farther east.

Mr. Howie was not only a botanist of note, he was one who took much interest in municipal affairs. He deserves all credit for having introduced the Lyme-grass at the Links. I gathered from his conversation that his attention was directed to the grass by his having read of its sand-binding powers in Holland. Provost Playfair was projecting a scheme for the conversion of the East Bents into a street to be called Victoria Terrace. It occurred to Mr. Howie that it would serve a good purpose to sow the Lyme-grass there, and accordingly he sent to Holland for seed. The Upper Harbour was being cleaned out at the time, and Mr. Howie gave instructions to have a layer of the mud laid over the seeds. The layer, however, was too thick, and it took more than a year for the seeds to germinate. I have no means of knowing whether the Lyme-grass growing now at the East Sands was derived from the plants grown from the Dutch seed. Mr. Howie then turned his attention to the Links as a suitable place to establish the grass. I learn that he was probably prompted to sow the seed there through a discussion in the Town Council regarding the need of protecting the High Hole green from erosion by the waves in stormy weather. Many can still remember when it was necessary to keep the steep bank at the High Hole protected by timber. When a ball overran the green it fell on the smooth sand below. A considerable quantity of seed—8 lb. I think—was sown in the neighbourhood of the hole. Now the hazard of the shelly foreshore is 18 yards from the edge of the old green, and a new green has been made at a lower level on ground reclaimed by Lyme-grass. I reckon, from records referring to the operations at the Harbour, that the date of sowing was 1847.

The Lyme-grass, spreading to right and left, now forms a strip extending from the Swilcan Burn the whole length of the West Sands, round the "Outhead," and along the shore of the Eden—in all, a distance of a little over two miles. The widest part of the reclaimed ground is at the targets, where the old shore-line is now 160 yards inland. The continuity is broken at present by a gap about 70 yards in length opposite, and to the west of, the west groin which has been recently erected to protect the course at the mouth of the Eden. It is certain that there would be no gap before the erosion of the foreshore took place. To the west of the hiatus the grass is seen in the turf above, and in portions of the sod which have fallen after undermining. Here and there healthy plants are growing at the foot of the eroded face. At the point to the west where erosion ceases, reclamation begins, and a large wreath of sand, which has gathered round and half-smothered the grass, has been formed there. For a distance of 200 yards west of the High Hole green the grass is busy at reclamation work, and a narrow band of it extends westward as far again.

It must not be thought that Nature has been unassisted. It has come to my knowledge that more than one philanthropist has been sowing, if not ploughing, the sands, with advantage to their fellows. In this connection I have to mention the names of the late Mr. George Bruce and the late Mr. William Doig. The latter, I understand, deserved the credit of bringing the grass round the Outhead from the estuary to the Sands. His method was to lay down entire seed-bearing ears and cover them up with sand. In more recent years the helpful work has been actively but unobtrusively carried on by Mr. George Bruce, junior.

The Sea Lyme-grass is a much stronger plant than the Marram. The leaves resemble those of Marram in being very hard in their texture, but they are fairly flat. The ears are large, and not unlike wheat. The base of the stem when young contains so much sugar as to have a sweet taste. This plant has grown with great vigour on the foreshore. It must have fresh fields if it is to retain its vigour, and, when available, it occupies them with surprising aggressiveness. On the other hand, when none can be reached, and it is compelled to remain in the same ground, it rapidly deteriorates, and its place is taken by finer grasses and other turf-forming plants.

One peculiar result, or perhaps concomitant, of the weakening of the plant is the infestation of it by a **Smut Fungus** (*Ustilago hypodytes*) (Plate IV., fig. 8). This Smut is allied to the familiar one of the Oat ears. Here, however, it is not the ears, but the parts of the stem sheltered by the sheaths of the leaves, that form the region of spore-production by the parasite. The affected shoot is very greatly altered. The normal ear (fig. 3) is borne on a stem formed of a few long internodes, but in the diseased shoot (fig. 8), in place of the ear, the upper part of the stem, where the ear ought to be, is changed into a series of short nodes, covered for the most part by leaf-sheaths without blades. The nodes become shorter and shorter as they ascend, and at the top there is a flattened,

are called. Those produced on the lower side have to find their way upwards by bending as they grow. Only the heads are seen projecting from the soil.

When the heads are fully matured, and we bend closely over them to study them with a lens, we need not be surprised if we see little puffs of vapour ejected vigorously from them and dissipate instantly. The vapour is composed of microscopic spores which are shot naturally from cavities sunk in the heads. The spores are wafted to flowers of the grass, and there they germinate. The fungus filaments produced, fine as they are, become woven together and finally compacted to form the Ergot, and thus complete the cycle. While the Ergot is in course of formation other spores are given off from its exterior, accompanied by a sweet-smelling viscid fluid which is very attractive to flies. When sipping the secretion, they become smeared with it. Alighting on fresh flowers, the flies infect a number of them with the spores they carry on their proboscis or elsewhere, and the result is the same as before—Ergots develop in place of, and at the expense of, grain. I have been able to observe that the Ergots do not all produce stromata the first season, some of them lying dormant and bearing their stromata the following season.

Besides the grasses mentioned, there are several other plants which aid materially in binding the sandy soil of the dunes. One of these is the **Sand Sedge** (*Carex arenaria*). It is extremely common all over the Links. Its leaves are often mistaken for those of a grass. They are long, narrow, channelled, rough-edged, and deep-green when fresh. The flower-stems are three-cornered. The spikes are brown, and 2 inches or more in length. This plant cannot be mistaken when it displays its mode of growth. Its underground runners proceed in straight lines, often for long distances, and give off leafy plants at regular intervals.

Another serviceable plant is the **Rest-harrow** or **Wild Liquorice** (*Ononis arvensis* or *O. repens*) (Plate IV., fig. 7). Its branches spread round in a recumbent position. Its leaves are dark-green, and very well clothed with hairs. A peculiar odour is emitted from the leaves when they are bruised. The pea-shaped flowers are about the size of those of the Whin, but pinkish-purple. The roots are extremely strong, and penetrate to a great depth. It is to them that the plant owes its capabilities as a sand-binder. They are not unlike the much longer roots of the Liquorice proper (*Glycyrrhiza*), and they contain much of a similar sugary juice not unpalatable to some people.

Yet another plant assisting in holding the sand together is the **Lesser Meadow-Rue** (*Thalictrum minus*). This plant (Plate IV., fig. 10) cannot be mistaken for any other, either in foliage or flower. It at once arrests attention on account of the general resemblance its leaves bear to the Maiden-Hair Fern (*Adiantum*). They are, however, much deeper green, and their texture is very much firmer. The firmness or hardness of the texture, as already indicated, is one of the outstanding peculiarities of the plant in its adaptation to its surroundings. Another feature is the tough and wiry nature of its roots, and the power they have of penetrating deeply into the sand. The flowers are borne as delicate, yellow tassels, little else being visible except stamens. It is not easy to perceive at first sight that this plant has any relationship with the Buttercup, but, in spite of the absence of a coloured perianth, it is a member of the Ranunculaceæ.

Not only are the dry dunes and their flora worthy of protection from the philistine—the sheltered hollows that exist among them are almost equally so. One of these cup-shaped hollows, explored lately, yielded the following species: Shining-fruited Rush (*Juncus lampocarpus*), Mud Rush (*J. Gerardi*), Glaucous Heath Sedge (*Carex* *glauca*), Yellow Sedge (*C. flava*), and the Great Sedge (*C. vulpina*), along with many commoner plants. The Bristle-stalked Club-rush (*Scirpus setaceus*), which used to be found in the hollows, seems to be extinct.

Before leaving the dunes it is fitting to mention that the late Rev. Mark L. Anderson, D.D., was the discoverer there of two fungi not previously recorded as British. The one (*Peziza ammophila*) was found attached to the roots of the Marram, and the other (*Agaricus (Psilocybe) ammophilus*) grew on the sandy ground.

A feature which distinguishes the older ground from the parts more recently reclaimed from the sea is the presence of earthworms. In some parts of the Old Course the earthworms occur in great numbers. Their presence is rendered visible by the little heaps of earth—the worm-casts—piled on the surface. The heaps are most evident when the courses are shut for rest or repairs for a time, being then left undisturbed by the broom and the roller, and the foot or club of the golfer. They are abundant in the damper hollows of certain parts of the courses. They also abound in other places—for instance, in the obliterated sheep-tracks, where, for some reason, perhaps the application of earth, they have multiplied.

An examination of the ground being reclaimed from the sea by the Lyme-grass shows the utter absence of earthworms in the new parts. They are only to be found in the regions where black soil has been deposited. They require to be introduced, and they will not succeed so long as the soil is pure sand. I think it can be shown that there are far fewer earthworms on the New Course and the Links part of the Jubilee Course than on the Old Course. It would seem certain that the longer a Course is used the more numerous the worms will become. Whatever enriches the soil in an agricultural direction is likely to help the worms to multiply.

not been interfered with. The inspection of, say, a square yard of the original sward may well suffice for a week's study, if all the plants composing it are to be dealt with as fully as might be. Not only are there grasses of many species present, but they have as neighbours and competitors numbers of other flowering-plants representing almost as many natural orders; and there are several species of mosses, and not a few liverworts, lichens, and fungi as well.

The grasses form the basis of the turf. If in flower they are not particularly difficult to identify, but if only showing their foliage, the task may be irksome enough. The grass which is clearly the most widespread is one with leaves not much thicker than threads (Plate IV., fig. 6). These are fairly stiff, and produced in dense tufts. The inflorescences are delicate brushes of small spikelets, and botanists can make out features so different from the ears of Marram and Lyme-grass as to merit generic distinction for the grass. To all who have lawns and golf-greens to make, our plant is well known as the **Fine-leaved Sheep's Fescue** (*Festuca ovina*, var. *tenuifolia*).

We are almost certain to see examples of another grass in plenty. Its leaves are strap-shaped, $\frac{1}{8}$ of an inch or a little more in width, and not nearly so numerous as those of the Fescue. Moreover, there is a tendency to produce runners or stolons, which ramify wherever they can around the parent plant. If in flower, there can be no mistake at all in the endeavour to identify this grass, for the ear or inflorescence is quite distinct from any other species we are likely to meet with. The stems are particularly wiry, about a foot in height, and the ear is composed of spikelets which are not disposed equally on all sides, but in a somewhat one-sided fashion. When a few of the spikelets are rubbed off, there will be found amongst them remarkable comb-like structures which are present as supports to the flowers proper. On account of the peculiarities of the ear, this grass has been designated the **Crested Dog's-tail** (*Cynosurus cristatus*). The ears and their stalks are so hard and wiry that they are left by the sheep which crop the herbage of the Links, and they may be seen standing in considerable areas all the winter through. The seeds are thus left to ripen and spread the plant.

Our little patch may contain other grasses, but if not, others can be found readily enough near by. The **Mat-grass** (*Nardus stricta*)—(see Plate VII., fig. 5)—is one of the most important of the Links grasses. The leaves resemble those of the Sheep's Fescue, but are much more wiry. The **Common Bent-grass** (*Agrostis vulgaris*) occurs in large patches in many parts of the courses. It has a spreading, somewhat weedy habit. The bluish-green leaves lie flat on the ground. The panicles are delicately feathery, their colour reddish-purple. The **Sweet Vernal-grass** (*Anthoxanthum odoratum*) occurs everywhere. It is readily recognised at any time by the pleasant perfume of its leaves when they are bruised. The **Annual Meadow-grass** (*Poa annua*) is the most domesticated of our native species. It endeavours to form turf in garden walks, and even over the causeway of neglected streets. At the Links it does not take kindly to the "rough country." Its preference is for well-nourished putting-greens.

As a study in specific differences, the Hair-grasses may be chosen. The **Silvery Hair-grass** (*Aira caryophyllea*) has to be looked for in spring if it is to be found fresh, for it soon proves itself to be a very short-lived annual. It is a small, delicate grass, with stems only 5 or 6 inches in height. The **Early Hair-grass** (*Aira præcox*), of similar habits but even smaller in stature, and with a much more compact ear, is very visible, especially in its dead state, on the barer and drier parts of the courses. The **Tufted Hair-grass** (*Aira (Deschampsia) cæspitosa*), presenting an entirely different build, is to be met with in damp ground. It is one of our coarsest grasses, and easily recognised by its long, very narrow, strap-shaped, harsh or prickly leaves. The tall flower-panicles are not without elegance.

Besides the Rushes already mentioned as occupying the damp hollows amongst the dunes, other three may be observed on the Links, viz., the Heath Rush (*Juncus squarrosus*), the Common Rush (*J. conglomeratus*), and the Hard Rush (*J. glaucus*). The **Heath Rush** is the species most often seen by the golfer, because it forms an appreciable element in the natural turf of the courses. It forms low, compact tufts of numerous, firm, spreading leaves, and from the centre sends up rigid flower-scapes 6 to 12 inches in height. The **Common Rush** scarcely requires description. Its brown flowers are grouped in small hemispherical masses near the top of the tall stems. The **Hard Rush** resembles the Common Rush in being tall, but the stems are tougher and more slender, and the inflorescence is an open panicle.

The **Whin** or **Gorse** (*Ulex europæus*) differs from the other plants we are studying in being a shrub. Masses of it are dotted over the whole of the Links beyond the Swilcan Burn. The area now occupied by the New Course was previously covered in great part with Whins. When they were in bloom their subtle perfume could be detected at a long distance, and their rich gold formed a fine spectacle. Larks innumerable found sanctuary in the grassy patches amongst them, and the air was far fuller of their song than it is now. The Whins on the Links grow to very considerable height when allowed to do so. The influence of the sea near by keeps the climate sufficiently mild to prevent severe damage to them by frost. They are often seen

The **Wild Thyme** (*Thymus Serpyllum*) is extremely plentiful, being thoroughly at home on the dry banks. It blooms in bright rosy purple patches at the same time as the Yellow Bedstraw is at its best.

Fairly well distributed is a plant which, when in flower, is seen to be an "everlasting," such as is used in Immortelles. The underside of the leaves is white and woolly. The plants usually succeed in occupying a considerable patch by themselves. This interesting species is the **Mountain Everlasting** (*Antennaria dioica*).

Another Composite, the **Mouse-ear Hawkweed** (*Hieracium Pilosella*), occurs in some places in large patches which occupy the ground almost exclusively. The common name refers to the form of the leaves. They are provided on the upper side with long, straight hairs which rise from the opposite surfaces and meet or cross in the middle. The under side is downy.

Mention has already been made of the occurrence of certain Plantains as weeds on lawns. On the greens we meet with another species, the **Buck's-horn Plantain** (*Plantago Coronopus*). It is a seaside plant, characterised by having narrow, deeply-lobed, hairy leaves. On the dry ground the leaves lie flat and escape the knives of the mower. Reference will be made to it again, in chap. ix.

Amongst the flowering-plants met with on the Links there is one, the **English Catchfly** (*Silene anglica*), which presents a unique peculiarity—its sporadic and uncertain occurrence. One may search in vain for several years and fail to find it. When found, it may be seen in goodly numbers. There is no fear of mistaking it. The flowers (Plate IV., fig. 5) proclaim it to be a relative of Sweet-william, for although they are not borne in trusses, as in that plant, they are similarly shaped and marked. The large inflated calyx leads us to see that it is a Campion or Catchfly. It is an annual, 2 to 3 inches high, and clothed with rough hairs. It prefers to grow where a thin coat of earth has been spread on the trodden Links.

The flora of the Links includes many other flowering-plants besides those described above, but want of space precludes further characterisation. The Heaths are, of course, one of the glories of the Links. Opportunity will be taken in the chapter on Tents Muir to make observations on them.

One of the most interesting native plants on the Links is a flowerless one, a member of the Fern family. It bears only a remote resemblance to an ordinary fern, and its habits are peculiar. Very few visitors to the Links, and even fewer golfers, ever observe the plant, although they crush it under foot. It appears amongst the grassy vegetation in May as a shining-green, solitary object, consisting of a stem bearing a branched leaf. One of the branches bears lunate or crescent-shaped pinnæ, and the other many small lobules. It rises only 2 or 3 inches above the ground. If it is dug up, the root is found to be pretty robust, and much at home in the sandy, fibrous soil, 1 or 2 inches beneath the surface This strange plant (Plate IV., fig. 11) is called the **Moonwort** (*Botrychium Lunaria*). The spores in the Wall-rue Fern have already been referred to. In the Moonwort the spore-cases appear in the lobules of the leaf. After the spores are shed, in August or earlier, the plant withers, and is lost to the Links until the following summer. The prothallus—the body produced when the spores germinate—is developed underground, and consists of a minute tuber-like mass of tissue, destitute of chlorophyll, and bearing the reproductive organs on its surface.

A very considerable variety of Mosses occur on the Links. Mosses are not made welcome on golf-greens or lawns. They usually indicate dampness, and sometimes sourness, in the soil. Mr. C. Howie, in his 'Moss Flora of Fife and Kinross,' has enumerated 300 species as native to those counties. Their peculiarities therefore call for specialised study. Thirty species have been recorded from the Links.

The Liverworts are closely related to the Mosses. Some of them are difficult at first sight to distinguish from the Mosses with which, not uncommonly, they are intermingled. The foliaceous Liverworts are usually delicate and translucent, and they shrivel greatly when dried. Certain of them occur in abundance.

Lichens form a large part of the vegetation of the Links. They are almost all of a grey hue, and their diversity of form is extraordinary. A species of extremely common occurrence is the so-called **Reindeer Moss** (*Cladonia rangiferina*). It is ash-coloured, 2 to 4 inches high, finely and freely branched, with the points of the branches nodding. The **Cup Lichen** (*C. pyxidata*) is cup-shaped, ashy-green, powdery, and usually about ½ an inch in height. A third form is exemplified in *Peltigera canina*. This species lies fairly flat on the grassy ground, as an irregularly-lobed and somewhat puckered sheet of rather papery tissue. The upper surface is greenish, the under side pure white, tomentose, and netted, with long tapering processes like roots slightly attached to the herbage. Lichens are remarkable in being plants composed of representatives of two distinct classes, the fungi and the algæ or water-weeds. By some strange ordering of Nature the two forms have discovered the secret of perfect reciprocity. What the one lacks the other can supply, and the result is the upbuilding of an organism which can thrive under the most trying conditions of life.

The **Fungi** are well represented on the Links. The Puff-balls (*Lycoperdon*) are most likely to attract attention, because of their resemblance to golf-balls. When young, a Puff-ball is a spherical or pear-shaped mass

A seasonal study of the Links affords no small meed of interest and charm. In January they present a grey tone, due to the predominance of such grasses as the Sheep's Fescue, the Crested Dog's-tail, the Bent Grass, and the Marram, whose leaves or stems, being of a firm texture, do not rot away. Many other grasses, and the sedges, rushes, and heather, in their withered and dormant condition, contribute largely, and the lichens in lesser degree. A fresher tint is given to considerable tracts by mosses of various kinds. Certain of them, *Dicranum* for instance, keep bright green if the weather is mild; others, including certain of the *Hypnums*, are lighter green, inclining to yellow. In March the daisies appear in fair numbers, and by the end of the month the Whitlow Grass sprinkles the freshening turf with its dusting of snow. In May and June wreaths of glowing gold captivate the eye, and declare the supremacy of the Whin. A bright mosaic of the purple of the Wild Thyme and the yellow of the Bedstraw, with the richer yellow and crimson of the Bird's-foot Trefoil not seldom super-added, is viewed through the tremulous heat of July. In the middle or towards the end of August the Heather flushes the Links with a fuller purple, and before long, through a kaleidoscopic mingling of autumnal browns, the colder greys are resumed.

PLATE V.

FIG.

1. Glasswort or Marsh Samphire at the estuary of the Eden.
2. Sea Pink (*Armeria maritima*).
3. Reed Canary-grass (*Phalaris arundinacea*).
4. Seaside Plantain (*Plantago maritima*).
5. Prickly Saltwort (*Salsola Kali*).
6. Seaside Sandwort Spurrey (*Spergularia marina*).
7. Seaside Arrowgrass (*Triglochin maritimum*).
8. Sea Meadow-grass (*Glyceria (Poa) maritima*).
9. Seaside Michaelmas Daisy (*Aster Tripolium*).
10. Celery-leaved Crowfoot (*Ranunculus sceleratus*).
11. Common Reed (*Phragmites communis*).
12. Reed Meadow-grass (*Glyceria aquatica*).

Chapter V.

Plant Life of the Eden Estuary.

THE river Eden takes its rise in the parish of Strathmiglo, in the north-west of Fife, its head waters being derived from the confluence of several small streams there. It pursues a devious course through fertile valleys, and passes the county town, Cupar, as a stream of considerable size. Three miles and a half below this town, and five miles from the sea, it becomes tidal. Widening greatly, it passes under the old stone bridge and the railway bridge, and thereafter forms an estuary which at its widest point measures a mile and a quarter across. The river at low water meanders in a narrow bed, flanked with very wide mud-banks on both sides; and near the sea, instead of continuing in a direct eastward course, it trends to the left and runs a long distance northwards, where the actual mouth is situated. The broad spit of sand between the river and the sea, known as the "bar of Eden," is a continuation of the West Sands of St. Andrews. The bar is covered to no great depth at high water. It suffices to break the violence of the waves in stormy weather, rendering the wide estuary inside a place of comparative quiet. When the tide recedes from the bar, it is usual to find there ripple-marks well worthy of more than passing study, by reason of their variety of design.

The estuary of the Eden is divisible into several regions with respect to its flora. Leaving out of account the purely aquatic flora, which includes the plankton of floating algæ, diatoms, and the like, and confining ourselves to plants requiring soil of some kind to grow in, we find that the region of the mud-flats, lying between tide-levels, is the home of a few most interesting plants which adapt themselves to the very peculiar conditions obtaining there. When the tide recedes and exposes the mud-flats, we find them in summer fairly well clothed with what looks extremely like long grass. It takes close inspection to satisfy oneself that this plant, the **Grass-wrack** (*Zostera marina*), is not a grass. The leaves are strap-shaped, brownish-green, and somewhat translucent. The illustration (see Plate VI., fig. 2) shows a few plants taken from the estuary, and floated in a dish of water. The flowers, although present, are too small to be observed in the figure. They do not rise on a stalk, but remain in a sheath or spathe which is open along one side. They are greatly reduced in structure, and consist of only one stamen and one carpel placed on the same level, and borne alternately in two vertical rows. The pollen-grains are shed when the tide is in. On liberation they immediately lengthen into thread-like tubes, and, being of the same specific gravity as the sea-water, are carried about by currents. The stigmas are large, and likely to capture these lengthened pollen-grains. The creeping rhizomes and fibrous roots fix the plants firmly in the mud. The Grass-wrack is related to the Pondweeds or Potamogetons. The plant is of some economic service, the leaves being used as a packing material, and even as stuffing for cushions and mattresses.

Higher up the estuary, closer to the shore, and in a much more restricted region, a very remarkable miniature forest of strange plants growing by themselves (Plate

When in quest of the Grass-wrack and Glasswort we have been moving about in the somewhat soft mud, choosing our steps with due care so as to avoid sinking to the ankles in the unpleasantly adhesive soil which suits those plants. We step with pleasure on the bank of more solid soil raised a foot or two above the mud-flats and covered with close grassy vegetation. The banks constitute what are locally called the salt-grass flats, and they occupy a large space, stretching from the edge of the mud-flats to the sandy strand (see Plate VI., fig. 3). Here we have one of the most interesting ecological features of the estuary. The soil, a dense blue clay with a considerable proportion of sand, is held together by the roots of the vegetation which flourishes on it. It is subjected to very little erosion, because the banks occupy a quiet place where the waves exercise no great force. The region is traversed by crevasses, and is dotted thickly with small basins. The basins stand full of brackish water between tides, in neap-tides for many days without renewal. The algal flora of the basins is well worthy of study, but this we must pass by in the meantime.

The turf seems almost all composed of one species of grass (Plate V., fig. 8). It forms a close sward over large areas of the drier ground, but in the hollows and muddier parts it exhibits a coarse habit of growth. The leaves of strong plants are distichous, spreading, 2 or 3 inches long, narrow, channelled, acute, and succulent. The flower-stems are 6 to 12 inches in height, the panicle erect, 2 or 3 inches long, and the branches unilateral. A study of the spikelets shows that this grass is a relative of the Annual Meadow-grass. It is named the **Sea Meadow-grass** (*Glyceria (Poa) maritima*). The formation of the salt-grass flats is chiefly due to the growth of this grass.

As one proceeds towards the sandy inner edge of the flats, one becomes aware that there is a change, although almost imperceptible, in the character of the turf, and if careful inspection of it is made, where it has reached ordinary *terra firma*, it will be perceived that the Seaside Meadow-grass must have been left behind and another taken its place. The grass we are now inspecting is the **Fine-leaved Sheep's Fescue**, the well-known Links grass (see Plate IV., fig. 6). It takes some care and experience to discriminate between the two grasses where their territories overlap, and when dwarfed or nibbled foliage only is available. To be certain it is well to use the lens. One feature revealed by the hand lens seems quite reliable, namely, the presence of minute marginal silicious prickles in the Fescue, and none in the Meadow-grass. The microscopic structure of the leaves discloses distinctive characters, the cell-walls of those of the Fescue being crumpled, and of the Meadow-grass straight.

It is of some practical moment to know the difference between the two grasses, for cases have occurred oftener than once in St. Andrews where, tempted by the fine smooth appearance of the turf of the salt-grass flats, cartloads of it have been taken for making bowling-greens and lawns, with results that have not been satisfactory. The Seaside Meadow-grass is far from home in a bowling-green. It misses the dampness and salt at its roots, and naturally refuses to be cajoled into vigour in the commonplace environment of an inland lawn.

Amongst the grass we notice compact and isolated patches of stiffer leaves in rosettes. In winter those leaves are extremely short. If we dig into the patches, we find that the rosettes are borne by stout root-like axes which penetrate the mud to a very considerable depth and are clothed with the withered bases of older leaves. If we visit the same patches in the early summer we find them glowing with the charming flower-heads of the **Sea Pink or Thrift**, locally called the Sea Daisy (Plate V., fig. 2).

The Sea Pink (*Armeria maritima*) is peculiar in making itself at home in rocky, dry places on the coast as well as on the mud-flats. No one need be told that it is a typical seaside plant, but it almost requires ocular demonstration to believe that it is also to be found high up on most of our Bens—"the most humble and most lofty of plants," as Lightfoot neatly puts it in his 'Flora Scotica.' The plant is not met with in the intermediate altitudes.

The Sea Pink and its allies, it matters not from what part of the world they come, are characterised by a microscopic feature in their leaves which renders it possible to recognise their family relationship at once, namely, the presence of minute glands all over the surface. In some of the species water charged with lime in solution finds exit and is deposited at the mouth of the glands and rendered visible as specks of chalk. But besides those glands there are others found in many of the Sea Pink family (Plumbagineæ), confined for the most part to the axils of the leaves. The axillary glands are much larger than the above, and in some foreign members of the family their function is to secrete a large quantity of mucilage, which may not uncommonly be seen gliding down the stem, or hanging in desiccated shreds when the weather is dry. In the Sea Lavenders (*Statice*), of which examples are still to be found on certain parts of the coast of Scotland, although no longer on the Fife coast, the mucilaginous secretion is seen with the naked eye when the leaves are pulled outwards a little from the stem. The presence of these glands is most certainly connected with the conditions in which the Sea Pink and its allies grow. The chalk-secreting glands seem to act as a means of ridding the plant of effete or injurious substances. The mucilage glands may help in regulating transpiration. The mucilage spreads when liquefied by

widely separated systematically. In the flower of the Plantain, the petals are 4, scarious, spreading; the stamens 4, with long filaments; the style simple, long; the fruit a capsule, opening transversely by a lid. In the Arrowgrass the perianth is of 6 concave deciduous segments; the stamens 6, with short filaments; the stigmas 6, forming a feathery tuft; and the fruit of 6 carpels, separating from a central column.

In parts of the marsh to which more fresh water finds its way we meet with the **Marsh Arrowgrass** (*Triglochin palustre*). It is distinguished from the Sea Arrowgrass by its narrow, somewhat rush-like, brighter green leaves. Its spike is composed of fewer flowers, rather closely set at first, but well separated when the fruit is fully developed. The fruit is more elongated than in the other species, and when ripe it splits into three carpels. The Arrowgrasses are placed by some authorities in the same group as the Grass-wrack.

One of the commonest of seaside plants occurring in sandy places as well as in the salt marshes is the **Black Saltwort** or **Sea Milkwort** (*Glaux maritima*). It is perennial, its rootstock creeping and occupying considerable patches. The stems are decumbent, the leaves oval or oblong, opposite, fleshy, and glabrous. The flowers are axillary, sessile, very small, and rose-pink. The calyx is the coloured part, the corolla being absent. The uninitiated would not imagine that there is any family connection between this neat spreading plant and the Primrose, but nevertheless the Black Saltwort is one of the Primulaceæ.

A plant almost always associated with the Sea Milkwort, but one of the Caryophyllaceæ, is the **Sea Purslane** (*Arenaria peploides*). It has the same spreading habit of growth, and in some places, especially where the soil is sandy or gravelly, forms tracts of some size. The leaves are much larger than those of Glaux, decussate, sessile, ovate, acute, and very fleshy. The flowers are few, solitary, white, and borne on very short pedicels.

From midsummer onwards the **Seaside Sandwort Spurrey** (*Spergularia marina*) (Plate V., fig. 6) helps to brighten the salt-grass. Its long tapering root penetrates the damp soil deeply, and from the crown numerous prostrate stems spread in all directions. The leaves are opposite, linear, semi-cylindrical, fleshy, and tapering to a point. The flowers, borne in forked racemes, are pale rose, shading into white at the centre.

It may be mentioned here that in the low-lying field above the Motray Bridge, where the soil had been turned up, there occurred recently crowds of the **Field Sandwort Spurrey** (*S. rubra*). It is a less robust plant than the seaside form, with smaller, purplish-rose flowers.

Mention has been made of the occurrence of the **Scurvy Grass** (*Cochlearia officinalis*) on the walls in St. Leonards School Grounds. It is to be found in abundance in many different situations in the neighbourhood of the sea, and its occurrence in the salt marshes is to be expected. It is very easily recognised. Its leaves are reniform or orbicular, cordate, entire, angulated, very fleshy, and glabrous. The flowers are white, and borne in short racemes. The pods are globular, and, when the valves fall, the median septa, so characteristic of the capsules of the Cruciferæ in general,—and noted for their size and sheen in Honesty,—remain. The plant owes its common name to the valuable antiscorbutic properties of its leaves. It is widely distributed in the colder regions of the Northern Hemisphere, and is one of our Alpines.

The **Horse-radish** (*Cochlearia Armoracia*) bears close kinship with the Scurvy Grass. Introduced by cultivation, it has become thoroughly naturalised in certain parts of Britain, preferring seaside situations.

The **Mud Rush** (*Juncus Gerardi*), found in small numbers in the hollows between the dunes at the West Sands, is present in great abundance in the salt-marshes on the south side of the railway line. It is easily distinguished from those of which descriptive notes have already been given, namely, the Common, the Hard, and the Heath Rush. It varies greatly in height according to the conditions of growth, but the average is not much over one foot. The flowers are borne in a loose panicle at the top of a slender erect stem, sometimes single, but usually united in small clusters. The leaves are very narrow, grooved, and shorter than the stem.

In the same marshes the **Great Sedge** (*Carex vulpina*) occurs, but very sparingly. It is much less difficult to recognise this sedge than most sedges, especially when it is in fruit. The leaves are linear, long, $\frac{1}{4}$-inch broad, flattened, with rough margins. The stem is sharply three-cornered, with concave sides, stiff, stout, and rough, 18 inches or more in height. The spikes are cylindrical, crowded, 1 inch or more long, with a basal setaceous bract. The spikelets at the top are male only. The fruit is flattened, spreading, and brown.

In the same place, and especially along the edges of the ditches, the **Distant** or **Loose Sedge** (*Carex distans*) occurs. This is a very much less robust plant than the Great Sedge. The leaves are much shorter than the stem, flat, firm, and $\frac{1}{6}$-inch broad. The stem is very slender, stiff, erect, smooth, 18 inches long, bearing a few spikelets distant from each other. The top spike consists of male flowers, and is linear-cylindrical. A small spike is sometimes placed close beneath it. The other spikes, 2 or 3 in number, are female, and ovoid or cylindrical-oblong.

On the sands are found a strange-looking group of plants comparable to nothing we know of in the garden.

leaves large and almost destitute of hairs. The flowers are only $\frac{1}{4}$-inch across. They never fail to produce abundance of seed. The young plants occur in crowds in the neighbourhood of the parents, and many of them survive. Although this plant is a denizen of the spongy marsh, it can thrive fairly well in the garden. Such was my experience with it when I transferred specimens from this place into the University Botanic Garden.

Plants found at home in salt marshes and similar places have been termed **halophytes** or salt-loving plants. Such plants growing in a soil charged with salt have a difficulty in absorbing a sufficiency of water to supply their needs. It requires the exercise of greater osmotic force to absorb salt water than fresh water. A soil soaked with sea-water is thus, so far as the plants in question are concerned, a dry soil. Plants growing in this "physiologically dry" soil assume characters similar to those whose habitat is an actually dry soil. Halophytes and xerophytes accordingly fall to be classed together. The characters common to both are succulence, scarcity of hairs (as a rule), reduction of the leaf-surface, etc. In certain natural orders, *e.g.*, Chenopodiaceæ, a large proportion of the genera and species are halophytic. On the other hand, other natural orders are characterised as being halophobous or salt-avoiding, *e.g.*, Ericaceæ. Many puzzling problems are presented by halophytes, such as the ability of certain of them to flourish very well when grown in the non-saline soil of the inland garden, and so forth. Garden plants become objects of much greater interest when they are made the subjects of observation with the view of elucidating problems of this kind. The halophyte occupies a place of great importance in the garden. We have to repair to the seaside to find the originals of many of our vegetables—the Cabbage, Radish, Sea-kale, Celery, Beet, Asparagus, etc. Their succulence, a halophytic feature, has been the chief means of recommending them to the cultivator's notice.

On the north side of the river we meet with most of the plants already described. In addition to those, many others worthy of note can be found. Well up, towards the confluence of the Motray with the Eden, the **Common Reed** (*Phragmites communis*) (Plate V., fig. 11) forms a jungle of considerable extent. Although it grows amongst the mud of the river margin, it can dispense with the salt-water bath. It is one of the most striking of the native grasses. Being seven or eight feet high, we are completely hidden by it as we thread our way amongst the stems. The dead stems are very light, and they are floated away and strewn on the sea-shore far from their place of growth. The flower panicles form shining, purple plumes 6 inches or more in length.

The **Reed Canary-grass** or **Ribbon Grass** (*Phalaris arundinacea*) (Plate V., fig. 3) grows near by, but much less abundantly. It is not so robust. The panicles are open at first, but later fairly dense. Their colour is much lighter than that of the panicles of the Common Reed. A variety with variegated foliage is a favourite in gardens, under the name of Gardener's Garters.

In the same region, but well above the reach of the salt water, a considerable plot of the **Reed Meadow-grass** (*Glyceria aquatica*) (Plate V., fig. 12) occurs. It in no way resembles its congener, the Sea Meadow-grass (*G. maritima*), which forms a coarse turf in the neighbourhood. The Reed Meadow-grass is a particularly handsome species. Specimens have been gathered at the Eden over 7 feet high. The stems are erect and rigid; the leaves stiff, parallel-sided, and abruptly pointed; the panicles large, pyramidal, lax, and yellowish-green.

Many interesting plants have made their home on the dry banks which flank the river. Amongst them is one of rather uncommon occurrence in the neighbourhood, —the **Dyer's Weed** or **Weld** (*Reseda Luteola*). The resemblance of this species to the garden Mignonette (*Reseda odorata*), a native of Egypt, is considerable, both in foliage and flower. The Dyer's Weed, however, is 3 feet or more in height, and it is entirely lacking in perfume. It was formerly used as a source of yellow dye.

The **Common Valerian** (*Valeriana officinalis*) is abundant. Its height is 3 to 4 feet. The leaves are opposite, and all pinnate; the stem solitary; the inflorescence a flat corymbose cyme; the flowers pale rose; the corolla $\frac{1}{6}$-inch across; the tube gibbous; the fruit small, one-seeded, and crowned with a silky plume derived from the calyx.

At one part in a wet place the **Gipsy-wort** (*Lycopus europæus*) may still be studied. Its kinship with the mint and sage can at once be detected. Its erect four-angled stems arise from a creeping rootstock. The leaves are ovate-lanceolate, and very deeply toothed. The flowers are white, borne in closely-packed, axillary clusters. This plant has long had a reputation as a dye-yielding plant. Gerarde says: "Some also thinke good to call it Herba Ægyptia, because they that feine themselves Egyptians (such as many times wander like vagabonds from citie to citie in Germany and other places) do use with this herb to give themselves a swart colour, such as the Egyptians and the people of Africke are of; for the juice of this herb doth die every thing with this kinde of colour."

The **Hemlock Water-Dropwort** (*Œnanthe crocata*) is a plant which has become far too common on the north side. Not many years ago there were only one or two clumps. It is a vigorous umbelliferous plant, 4 feet high,

Chapter VI.

Animal Life of the Eden Estuary.

In the earlier excursion to the West Sands, we familiarised ourselves with many of the shells which might appropriately have been left for study until we visited the estuary of the Eden. The shells in question are scattered sparsely on the Sands, but over a long tract of the strand of the Eden they lie in masses at high-water mark, and constitute the so-called **Shelly Beds.** The beds occupy a great bight or bay well sheltered from severe wave-action. The moderate action to which they are exposed washes the sand from the shells, and leaves them heaped together.

A fine silvery deposit on the smooth areas beneath the beds, composed of particles requiring the lens to distinguish them, is well worthy of attention. It contains extremely beautiful objects, the microscopic shells of **Foraminifera,** a group of unicellular animals occupying a very lowly position in the scale of life. The shells are pierced by exceedingly minute pores, and through these protrude strands of protoplasm which function as a means of locomotion and the absorption of food. It may be mentioned that chalk is composed almost entirely of the shells of Foraminifers.

The shelly strand slopes downwards to the muddy floor of the estuary, and forms a region the conchologist

PLATE VI.

FIG.

1. Shells on the strand at the Eden.
2. Grass-wrack (*Zostera marina*).
3. Salt-grass Flats at the Eden.
4. Dog Periwinkle (*Purpura lapillus*), and its egg-capsules.
5. Mussel shells broken by the Oystercatcher.
6. Common Mussel (*Mytilus edulis*), with byssus or beard.
7. Stages in the life-history of the Mussel.
8. *Chenopus (Aporrhais) pes-pelecani.*
9. Mussel shells pierced by *Purpura*.
10. Foot of (A) Black-headed Gull; (B) Oystercatcher.

will not soon weary of. The shells are in the great majority of cases fragmentary, but there are, nevertheless, plenty of whole specimens to choose from. The portion of the surface illustrated (Plate VI., fig. 1) will serve to give a general idea of the composition of the beds. Several shells already named appear, amongst them being small examples of the Sabre Razor-shell (*Solen ensis*). A shell figured separately (Plate VI., fig. 8), and common enough, is the **Pelican's-foot** (*Chenopus (Aporrhais) pes-pelecani*).

One fully expects, of course, to see numerous examples of the **Common Cockle** and the Common Mussel there. Cockles are to be found by scraping amongst the sandy mud, in places where the mussels have not congregated. They lie immediately beneath the surface, and are invisible until exposed by digging or raking. Their lair can be located by the existence of a slit-like opening in the surface of the mud. When the tide covers their retreat, they emerge so far as to be visible, and, gaping a little, they can be captured by thrusting a pointed instrument between the valves. Many of them are stained a bluish colour, like the tint of the mud itself. Cockles were probably more numerous in days gone-by than they are now, for masses of their shells go to form a considerable part of the Links where they border on the Eden. This shell-fish, largely used as an article of dietary at the present day, was in all probability in greater request in the past, at all events in the days when the "kitchen midden" was a domestic feature, and, later, when such "shell mounds" as are seen on Tents Muir were accumulated.

The life-history of the Cockle is essentially the same as that of the Common Mussel outlined below. Passing a part of its youth in freedom as a swimmer, it differs from the Mussel in having a very much smaller area in which it may settle down with hopes of success. When well grown, the Cockle possesses a much larger foot than the Mussel, this being necessary to render it an effective digging implement. The Cockle, unlike the Mussel, is not possessed of a byssus, as it is not subject to the risk of being torn from its home by currents, as the Mussel is.

However familiar the Cockle is to the inhabitants of St. Andrews, the **Common Mussel** is far more so. From time immemorial, heaps of their shells have occupied the Fishergate at the "Ladyhead" in St. Andrews, and the baiting of the lines with Mussels by the fisher-folk at their doors is one of the characteristic sights of the city. In this occupation the operators become highly expert at scooping out the "fish" from its shell. The knife is inserted at the narrow chink on the straight edge of the shell, and a sweep first to one side and then to the other ensures the severance of the attachment of the mantle, and the two adductor muscles which close the shell. The empty shells find their way amongst the city refuse, and are ultimately scattered over the fields, their presence visibly attesting the proximity of Mussel fisheries. Considerable quantities of Mussels from the Eden are carted to the fishing towns of the "Coast," ten miles or more away.

The **Mussel Scalps,** or "Scaups" as the beds are called, have been the property of the city for centuries. The "Scaups" are only seen when the tide recedes. They then present from the shore the appearance of black banks —noticeable in the distance in Plate VI., fig. 3. The Mussels do not succeed if the beds become too high or too sandy. They cling to each other in dense masses by means of their byssus or beard, an apparatus remarkably well adapted for the purpose in view. It consists of a varying number of extremely delicate, but singularly strong, horny, elastic fibres, which are formed by a secretion from a special

the instance of the Fishery Board for Scotland, at the old Marine Laboratory. The eggs were fertilised while they lay in watch-glasses filled with sea-water. The illustrations (Plate VI., fig. 7) show a few stages in the life-history of the Mussel. The study of the developing embryos was prosecuted by examining them at short intervals under the microscope. At first the egg is a simple opaque sphere (A). In an hour or two it segments into halves. This is followed by the division of one half into a number of cells, while the other remains undivided (B). Multiplication of the cells goes on, until a structure not unlike a raspberry in form is evolved. It is translucent, and clothed with cilia which cause it to rotate (C). In the next stage, an oval outline is assumed, and at one end a cap-like portion is differentiated to form a large swimming organ termed the velum. This consists of a circlet of delicate bristles which, by vibrating rapidly in concert, propel the embryo forward swiftly. In the centre of the velum there is a single very long bristle which functions as a feeler. This highly interesting stage is reached in twenty-four hours. The valves of the shell then make their appearance, and for a considerable period the embryo is too large to be accommodated within them. The velum now constitutes a large part of the embryo (D). In the course of twelve days the Mussel has so far developed (E) as to possess the rudiments of a stomach and liver. The velum still remains very large, and swimming rapidly to and fro, by means of that great propulsive organ, is the chief business of the young shell-fish. All its movements display a high degree of sensitiveness. On the slightest indication of danger it jerks its whole body instantly within its glassy shell, and refuses to expand again until the cause of alarm is removed. In a few weeks the prismatic blue shell begins to appear, the velum atrophies, and the Mussel relinquishes its roving, natatorial life for a much more tranquil one. It now sinks, and attaches itself to solid objects wherever it can find them. The foot is, in the young Mussel, an organ which is not only highly extensile, but distinctly adhesive. By means of it the Mussel can creep about from place to place. By-and-by the beard or byssus is produced, and a more strictly sedentary life adopted.

Great stretches of rock all along the coast are rendered black with the dense covering of small Mussels. They have been carried there by currents, and of course they may have aided their progress so far by swimming when young. It is obvious that enormous numbers of Mussels must move from place to place. I have had embryonic specimens given me which were taken from the surface of the sea several miles beyond the Bell Rock Lighthouse. It must not be thought, however, that the little Mussels which cover our rocks have necessarily come from the Mussel-beds of the Eden, or the Tay. I found the very small and obviously dwarfed Mussels on the rocks quite capable of reproducing their kind.

In **Mussel cultivation,** advantage is taken of the deposition of the "spat"—as the young Mussels collectively are called—in certain unoccupied beds. They may be permitted to remain there and grow to marketable size; or they may be transferred to beds which require replenishing. The term "seed" is given to Mussels used in laying down new beds. Mussels taken for this purpose are from ½-inch to 1 inch in length. In harvesting the Mussels, the beds are reached at suitable states of the tide by boat, and they are raked up and brought to the shore, to await the arrival of the carts which are to convey them away.

I am indebted to Mr. Thomas Brown, the Superintendent of the Mussel-beds at the Eden, for observations he made on the rate of growth of the Mussels during a period of eighteen months, commencing with the young "spat," and carefully taking samples from the same place, on the same day of the month, from July of one year till October of the following year. When he commenced his observations, the Mussels averaged about one-twentieth of an inch in length. They were then held to be four months, or at most five months, old. He found that they developed very rapidly from July to December. Then ensued a time of very little growth during January, February, and March, and even April and May. This was followed by a period of very rapid development in June, July, and August, with a marked slackening in September and October. At a year old their average length was about half an inch, and in eighteen months 1½ inch. That is to say, Mussels, if left undisturbed, can be grown to a saleable size in eighteen months. It should be borne in mind that suitable conditions must be afforded them if they are to attain to that size. Mussels take longer to develop if they are put on ground from which a crop has recently been taken. On ground continuously cropped they may refuse to grow, and indeed, may die off altogether. The ground should lie at least a year after a crop is taken, before a new crop is laid down.

Referring to the possibilities of growth, when proper conditions can be given, Mr. Brown relates that on one occasion he took several boatloads of the little stunted Mussels from the rocks near the city, wherewith to seed the scalps, and they developed to saleable size. He is of opinion that they do not develop on the rocks, simply because of the want of shelter from the waves, and not for lack of food; and, moreover, he believes that satisfactory development does not depend on the supply of fresh water. The Mussel attains to its greatest development in the bed of the river, where it is always under

appreciable measure affected either the flora or the fauna of the Eden.

The Mussel is not without its **enemies.** The most destructive is probably the common five-rayed Cross-fish (*Asterias rubens*). In some years the damage it does is comparatively little, but in others it is enormous. One would not imagine that this harmless-looking creature possessed the means of devouring a well-grown Mussel. It is, however, able to close over, and, by eversion of its stomach, to engulf the shell and extract the animal.

Another serious marauder is the **Dog Periwinkle** or **White Whelk** (*Purpura lapillus*) (Plate VI., fig. 4). This predaceous mollusc is well protected itself by its very thick, coarse shell. On the rocks, and in other places where it is found, it occurs in great numbers. There is no difficulty in finding the egg-capsules (fig. 4) at any time of the year. They appear in some sheltered nook as a patch of small yellowish or pinkish, oval flasks, composed of tough membrane, each with a short stalk, and attached singly to the rock. Each capsule contains numerous eggs, many of which survive and develop. The vesicles open by a circular apical aperture, through which, after a period of several months of embryonic life, the young shell-fish find exit. The capsules are produced all the year round, and one Purpura has been known to produce over 200 of them.

The Mussel is a favourite food of Purpura. It is able to pierce the shell and feed on the inmate. The aperture it makes is a very small one (Plate VI., fig. 9), but the workmanship is perfect. The drilling is performed by means of the lingual ribbon or radula, a rasp-like apparatus situated in the mouth. Observers have noticed that the operation can be accomplished in about two days. It is immaterial what part of the Mussel shell is perforated, the proboscis of Purpura, wherever inserted, being long enough to reach any part of the prey.

Many other shells besides the Mussel are perforated by Purpura, for example, the Radiated Trough Shell, the Striped Sunset-shell, the Common Wedge-shell, etc. A search of a few minutes on the shore suffices to find examples of the slayer's work.

This mollusc is interesting in quite another way. The name *Purpura* has been given because this and the other species forming the genus secrete a substance which can be used as a **purple dye.** The famous Tyrian purple was prepared from certain species of *Purpura* and *Murex*. The "purple gland" is a yellowish mass situated behind the head, in the upper wall of the mantle cavity. The secretion is almost colourless at first, but, when exposed to the light and air, it very quickly passes through successive tints of cream, yellow, green, and blue, and finally assumes the royal-purple colour. It must have involved the death of a very large number of those shell-fish to supply the quantity of purple necessary to dye a royal robe.

To an entirely different class belongs a third marauder. One finds many Mussel shells with large pieces cut out of their sides (Plate VI., fig. 5), the work of the **Oystercatcher** (*Hæmatopus ostralegus*), called by fishermen the Mussel Picker, and by the older writers the Sea-Pie. This interesting bird is to be seen in considerable numbers at the Eden. The head, the entire throat, the upper part of the back, and the end of the tail are black; while the lower part of the back, the upper part of the tail, and the under surface of the body are pure white. The legs are reddish. The foot (Plate VI., fig. 10 B) is that of a wader. The three toes are slightly webbed. The fourth toe is absent. The Oystercatcher is an excellent runner and a good swimmer. It appears in the month of August, and retires to the nesting-ground in April. Large numbers nest in Perthshire, along the banks of the Tay. A favourite food is the limpet. The bird is said to watch when the limpet raises the edge of its shell, when it suddenly inserts its long, thin, wedge-shaped bill, and dislodges the shell-fish.

It is beyond the scope of the present work to admit of more than brief reference to a number of the birds which frequent the estuary. Certain of them will be mentioned in the chapter on Tents Muir. Unless when indicated to be otherwise, the descriptive notes given below refer to the male birds only.

The **Scaup Duck** (*Fuligula marila*), according to some, has received its popular name on account of its habit of frequenting oyster and mussel scalps or scaups; others assert that it is derived from the peculiarity of its call,—a hoarse note, accompanied by a characteristic toss of the head. The bill of the male is pale blue, with a black nail; the head and neck greenish-black; the wing bar white. The female is almost as large as the male. Its head and neck are dark brown, and there is a broad band of yellowish-white at the base of the bill. Large numbers of this duck used to come to our shores, but fewer come now. They arrive about November, and take their departure late in spring. The last birds leave in June. They dive in a considerable depth of water, and search in the mud with their beak for their food. They live largely on mussels. A duck has been taken at the Eden with a full-sized mussel in its throat. The Scaup Duck has been reported to have bred on Loch Leven.

Closely related to the Scaup Duck is the **Tufted Duck** (*Fuligula cristata*). It derives its name from the presence in the male of a crest or tuft of black feathers with purple and green sheen. Single birds are to be observed at the

The eggs are 10 to 14 or more in number, and their colour is almost pure white.

The **Teal** (*Querquedula crecca*) is the smallest of our ducks. The male is very brightly coloured. The top of the head, the sides of the face, and the throat are chestnut. A line of light buff passes above the eye, and another, almost white, passes below. A patch of glossy green extends backwards from behind the eye, between the two light bands. The back is chiefly darkish-grey, and the under surface of the body is creamy-white. The Teal delights in feeding on the seeds of estuarine plants. It breeds on Tents Muir. The nest is generally placed in the vicinity of a marsh, and is composed for the most part of grass, and lined with down. The eggs, 8 to 12 in number, are usually greenish-white. The female is very careful of her young, and will fly round an intruder's feet, and endeavour to lead him away by feigning a wounded condition.

Although not a sea bird, the **Mallard** or **Wild Duck** (*Anas boschas*) may be mentioned here. It only frequents the shore when frost prevents it obtaining food in its inland haunts. The drake is a finely coloured bird, and like its derivative, the domestic drake, is distinguished by the upward curl of the middle feathers of the tail. The wing bar is rich purple. In summer the plumage of the male resembles that of the female. The nest is placed on a dry bank, or amongst heather, near water. The female will sit until she is almost stepped on. The eggs number 10 to 12 or more, and are of a greenish-white colour, with a smooth shell.

The **Pintail Duck** (*Dafila acuta*), also called the Sea Pheasant, is so designated on account of its possessing a long tail. The neck is elongated, and so slender that the taxidermist, finding it impracticable to pass the skull through it, has to resort to the expedient of cutting off the head. The Pintail comes to the estuary in the winter. It breeds in at least one place in Scotland.

The **Shoveller** (*Spatula clypeata*), also named the Broad-bill, may be seen in the Eden in winter. It is a brightly-coloured bird, easily recognised by the broad dilatation at the end of the bill. In collecting its food on land or in shallow water, the sensitiveness of the lamellæ of its mandibles enables it to select what is nutritious. The Shoveller breeds in several places in Scotland.

The **Wigeon** (*Mareca penelope*) arrives in September. Although it breeds in the north of Scotland, it is chiefly from Norway and Sweden that it comes. It returns to breed in the northern lochs about the beginning of May. The bill is shorter than the head, and is bluish, tipped with black. The crown of the head is creamy, and the cheeks and neck rich chestnut. The wing coverts are white with black tips, and the wing bar glossy green, edged with black. The tail is wedge-shaped. In the female the bill is darker, and the head and neck speckled with dark brown. The favourite food of the Wigeon is the Grass-wrack (Plate VI., fig. 2).

Another family of the Swimming Birds—the Laridæ—includes the Gulls and Terns. The **Black-headed Gull** (*Larus ridibundus*) may be chosen for remark. This is one of the most familiar of our sea birds. It may be seen at the shore from the month of August to the month of March, that being the period of its freedom from domestic cares. Its peculiar laughing cry has earned for it its scientific name. The trivial name indicates the distinguishing character of its plumage—the dark-coloured head. The cap may be considered a part of its nuptial dress. In September the dark tinge of the hood disappears, and during the winter the "Black-headed" Gull, as such, is no longer to be seen. There is, however, a remnant of the hood left in the form of a small dusky spot in front of the eye. The leg and foot are red; the hind toe is free, and moderately developed. The other toes are deeply webbed, and it is very obvious that the foot (Plate VI., fig. 10 A) is that of a swimmer. In April this gull repairs to some inland loch, it may be many miles from the sea, and embowered in forest trees, there to take up the onerous duties of housekeeping. I know of such a loch about twenty miles from St. Andrews, where hundreds of Black-headed Gulls congregate. The eggs of this Gull are laid in a flat nest, composed chiefly of grass and reeds placed on the ground or on a tuft of rushes. The eggs number 3, rarely more, and vary greatly in colour. Some are blue, others nearly white or brown. Some have a few dark spots, others have many. Unfortunately for the Gulls, the eggs are considered a table delicacy, and they accordingly find their way in basketfuls to the market, under the name of "plovers' eggs." The clamour of the gulls in their nesting-ground is very great. The Gulls go back to the sea almost immediately after the nesting-time is over—that is, towards the end of July.

In the family of the Divers (Colymbidæ) notice may be taken of two Grebes. The **Great-crested Grebe** (*Podiceps cristatus*) is distinguished by possessing a crest like two long ears, which can be erected at pleasure, and a large ruff round the neck, rust-red, edged with black. It sits upright like the Penguins. It is a somewhat rare visitor to the Eden. It breeds in Perthshire.

The **Dab-chick** or **Little Grebe** (*Podiceps fluviatilis*) is seen above the bridge at Guardbridge. It is extremely alert and agile. When shot at, it has been known to observe the flash and dive out of danger before the shot reached it. In this connection it is interesting to learn that an inch of water interposed between the surface and

to be heard at the Eden. The very long, slender, curved beak is a character not to be mistaken. The plumage is not unlike the lark's. The Curlew is with us all the year. It nests on Tents Muir, and in the uplands.

The **Redshank** (*Totanus calidris*) is also a resident. The crown of the head, the back of the neck, and the back are greyish-brown; the breast and the under surface of the body white, slightly streaked; the tail feathers white, barred transversely with dusky grey; the legs orange-red. It nests on the Muir in marshy places. The nest is hidden in a tuft of grass, and has a scanty lining of moss or grass. The eggs are 4 in number, and are about the size of a plover's. They are pear-shaped. The Redshank is a trouble to the sportsman, on account of its habit of raising a noisy alarm when his presence is detected. It may be mentioned that the Curlew has a similarly tantalising habit.

The **Dunlin** (*Tringa alpina*) is often popularly, but wrongly, called the Sandpiper. It is a small bird, not quite so large as a lark. The crown is chestnut; the chin white; the upper part of the breast greyish-white and mottled; the lower part darker; the legs and toes black. In winter there is much grey and white in the plumage. Its nests are to be found in many parts of Tents Muir. The nest is usually placed in a tuft of grass, and is thinly lined with grasses. It is about the size of the lark's, but the eggs, 4 in number, are about three times the size of that bird's. They are of a green colour, spotted, especially at the larger end, with brown spots. The Dunlins assemble in great flocks in the autumn. When disturbed they fly swiftly in a body out to sea, and wheel here and there in company, executing their movements with such perfect precision as to exhibit now a dark cloud and anon a gleam of white, according as their upper or under surface is turned to the observer.

PLATE VII.

FIG.

1. View of Tents Muir.
2. Scots Pine on Tents Muir.
3. Teachers' Nature Study Class at Tents Muir.
4. Common Ling (*Calluna (Erica) vulgaris*).
5. Mat-grass (*Nardus stricta*).
6. Nest of the Water-hen.
7. Common Club-moss (*Lycopodium clavatum*).
8. Cross-leaved Heath (*Erica tetralix*).
9. Nest of the Eider Duck.
10. Common Butterwort (*Pinguicula vulgaris*).
11. Tentacle of the Round-leaved Sundew (magnified).
12. Round-leaved Sundew (*Drosera rotundifolia*).

Chapter VII.

Tents Muir.

There is probably no finer stretch of seaside moorland in Scotland than that which extends from the estuary of the Eden to the estuary of the Tay, having a length of five miles, and an average width of two miles. The Eden forms its southern limit, the Tay its northern, and it is bounded on the east by the sea. On the west side—according to the account of Professor William Brown in 'Archæologia Scotica,' vol. ii.,—"about a mile beyond the village of Leuchars, and to the eastward of a ditch that runs southward by the back of the house of Earlshall, there is a large tract of level, swampy, sandy ground, lying between the rivers Eden and Tay, which bears the name of Sheuchy Dyke. . . . Within the limits of Sheuchy Dyke, and about a mile to the eastward of the ditch above mentioned, one enters upon the Tents Moors, comprehending a large tract of ground, where the Danes are said to have encamped, and afterwards settled." The sands, known generally as "Kinshaldy Sands," are of great extent, the sea receding at low-water far back on the level shore. The whole of the seaboard side is composed of sand-dunes, in great part of no considerable height, but for long distances of a fairly massive character. The highest accumulations of all are at a point near the mouth of the Eden, where a single hill, long known as "Jerusalem Knowe," is a conspicuous object, familiar to all golfers on St. Andrews Links.

To the north of this hill there is a considerable tract almost level with the beach, and in storms with high tides the sea covers much of it. Here the botanist finds two of the rarer plants of the district, namely, the **Baltic or Northern Rush** (*Juncus balticus*) and the **Curved Sedge** (*Carex incurva*). The former very closely resembles the Hard Rush, and, in a less degree, the Common Rush. It is a seaside species. Its rootstock does not form tufts, but creeps very extensively. The stems are few, hard, somewhat thin, 2½ feet high, with the pith continuous. The panicles are dense and few-flowered, and the flowers dark brown.

The Curved Sedge is found in patches amongst the sand, where there is but little other vegetation. The rootstock consists of long, much branched, creeping rhizomes. The stems, 3 or 4 inches, or at most 6 inches high, are curved upwards. The leaves, almost equal in length to the stem, are recurved. The spike is capitate, ovoid or pyramidal, and about 1 inch long.

In this region several of the sea birds—*e.g.*, the Terns, the Ringed Plover, etc.—nest. In most cases the eggs so closely resemble their surroundings as to be very difficult to see unless when at one's feet. The **Common Tern** (*Sterna fluviatilis*), also called the Sea Swallow, arrives in May. It nests in large numbers on the Moor, but particularly on the sandy foreshore. The nests may be found from the end of May to the end of July. They are merely shallow hollows scooped out of the surface of the ground, and lined with a few straws. The eggs, 3 in number, vary greatly in colour and markings. It has been observed that they are dark when the nest is on dried seaweed, greenish when on grass, and grey when on sand. Many eggs are destroyed by carrion-crows. The

doubt find much to repay his toil when this grand Moor was only a seaward part of the wilds which stretched from side to side of Caledonia.

The Sea Lyme-grass, although present in small quantity at one part of the Eden shore, is not met with again by the explorer of the coast until the estuary of the Tay is approached. Virtually the whole of the dunes are still in their original condition. Here the Marram-grass is seen at the work it has been accomplishing for centuries. It is probably to this grass that we in large measure owe the existence of the Moor. The long stretches of the dunes are the scene of the struggle between this plant and the gathering sand, the wiry leaves rising victorious from the engulfing mass. Not far from the Tay the traveller meets with the Lyme-grass pushing forward with its usual vigour. Many large knolls of sand, quite detached from the shore, are tenanted entirely by this grass. In course of time it will find its way southwards, and in all probability will act as it has done at the Links of St. Andrews, and reclaim large tracts of the foreshore.

A common feature of the Moor is the occurrence of ridges which run in a direction roughly parallel with the shore. The general surface is very flat, and there is very little fall for drainage. One or two streams traverse the Moor, and afford outlet for the drainage which has been carried on by digging ditches of considerable depth. This has had the effect of causing the disappearance of sheets of water which were common enough at one time. Some of them reappear temporarily in wet seasons. The largest of the sheets was called the Canal Loch; another, the Foremunt Loch. In the north-east corner there is still a chain of small pools which seem to be fairly permanent.

The pools and marshes are the haunts of the

Water-hen or Moor-hen (*Galinula chloropus*). This bird, a resident, is present in large numbers on the Moor. It usually builds its nest in a clump of rushes or the like (Plate VII., fig. 6). It is composed of reeds or rushes, and the eggs, which are 5 to 10 in number, are reddish-white, speckled all over with reddish-brown spots. The bird is deep brown on the back, and the under tail feathers are pure white. Two very distinctive characters are—the red garter above the knee, and the bright red frontal patch above the bill. The food of the Water-hen consists of worms, insects, and seeds.

In the neighbourhood of the marshes, along the edges of the ditches, and in somewhat drier places as well, one finds the **Round-leaved Sundew** (*Drosera rotundifolia*) fairly abundant. It is rather difficult to find, because it usually grows amongst vegetation of the same colour as itself, namely, red. The Bog Mosses (*Sphagnum*), for instance, for which it has a partiality in its acquaintanceship, have red-tipped shoots. The peculiarities of the Sundew have been very well known ever since Darwin wrote his famous work,—'Insectivorous Plants.' It is not without interest to recall the fact that this strange plant was quite a familiar one to the old herbalists. For this reason I have taken my illustration (Plate VII., fig. 12) direct from Gerarde's 'Herball.' In this work we find the following reference to our plant:—

"*Ros Solis folio rotundo.* Sun-Dew with round leaves.—Sun-Dew is a little herb, and groweth very low, it hath a few leaves standing upon slender stems, very small, something round, a little hollow, and like an eare-picker, hairy and reddish as be also the stems, having dew and moisture upon them at the driest time of the yeare, and when the Sun shineth hottest even at high noone; and a moneth after there spring up little stalks a hand breadth high, on which stand small whitish floures: the roots are very slender, and like unto haires.

"They grow in desart, sandie, and sunny places, but yet waterie, and seldome other-where than among the white marish mosse which groweth on the ground and also upon bogs."

Very few plants are found which have not captured one or more insects. The leaves form a rosette, and lie well spread out in all directions. Every leaf is studded along its edge, and all over its hollowed upper side, with processes which Darwin called tentacles, the average number being 192. The longest are towards the outside, the shortest in the centre. Each tentacle (Plate VII., fig. 11), as seen under the microscope, is a far more complex thing than a hair, inasmuch as a diverticulum of the fibro-vascular system, with spiral vessels, passes up the stalk, and ends in a group of spirally-thickened cells which occupy the centre of the head called the gland.

When in full vigour, the plant glistens in the sunshine, as if it were covered with dew. The gland of each tentacle carries a drop of extremely viscid fluid. Darwin suspected that the odour of the secretion was attractive to insects. The insects, chiefly dipterous flies, lured to the leaf by the secretion, become entangled in it, and their presence, and more especially their struggles, have the effect of bringing into play certain extraordinary powers possessed by the tentacles. They are seen to bend, not in a haphazard way, but in a way that suggests the sentient or purposive, namely, in the direction of the captured prey. Leaves can be found that present the extraordinary appearance of having the whole of the peripheral tentacles folded over towards the centre, where the prey lies. Further, the substantial blade of the leaf itself may be inflected so much as to form a cup. The sensitiveness appears to be confined to the glands and the

movement, as during a high wind the glands can hardly escape being occasionally brushed by the leaves of surrounding plants." It was further noted that the impact of drops of heavy rain did not bring about bending.

The transmission of stimulus from one tentacle to another is one of the many marvellous phenomena exhibited by the leaf. The excitement of a gland not only causes its own tentacle to bend,—the effect is seen in the bending of surrounding tentacles. Substances capable of affording food to the leaf cause much more energetic response than do inorganic bodies or mechanical irritation.

Darwin found that when the glands of the disc are stimulated in any way, but more especially by contact with an object containing nitrogenous matter, they secrete more copiously, and the secretion becomes acid: not only so, they transmit some influence to the glands of the outer tentacles which causes them to exhibit a like activity, their secretion also becoming acid. In addition to the acid in the secretion of excited glands, he demonstrated the presence of a ferment which he considered to be closely analogous to, if not identical with, the pepsin of the animal stomach. In virtue of the presence of the acid and the digestive ferment, the secretion carries on digestive action in the same way as gastric juice does.

Another of the insectivorous plants, and one of rather more common occurrence on the Moor, is the **Common Butterwort** (*Pinguicula vulgaris*). It is a plant much more easily seen, because its rosette of flat, yellowish-green leaves forms a fairly distinct contrast with the surroundings. Its mechanism for the capture and digestion of its prey is not so striking as in the Sundew, but it is, nevertheless, a highly interesting plant. Its flower is not unlike a small violet, and has a beauty all its own. The Butterwort, like the Sundew, was well known to the herbalists, and the figure given (Plate VII., fig. 10), as well as the subjoined description, are from Gerarde:—

"*Pinguicula sive Sanicula Eboracensis.* Butterwort, or Yorkshire Sanicle.—The second kind of Sanicle, which Clusius calleth *Pinguicula*, not before his time remembred, hath small thicke leaves, fat and ful of juyce, being broad towards the root, and sharpe towards the point, of a faint greene colour, and bitter in taste: out of the middest wherof sprouteth or shooteth up a naked slender stalke, nine inches long, every stalke bearing one floure and no more, sometimes white, and commonly of a blewish purple colour, fashioned like unto the Common *Consolida regalis*, having the like spur or Larks heele anexed thereto."

The Butterwort grows in company with the Sundew, but it prefers firmer soil. Although it luxuriates in a very moist place, good examples can be found in spots where, for a considerable period, the peaty ground may be fairly dry. It used to grow on a damp spot at the first hole on St. Andrews Links. In some parts of Tents Muir it is very abundant, as, for instance, in the region not far from the southern end, illustrated in Plate VII., fig. 3, where the members of my Nature Study Class of 1907 studied its habits.

The leaves afford a marked contrast to those of the Sundew, being very large and thick. The margins are more or less curled inwards. The surface, when touched by the finger, is found to be viscid. On careful examination, innumerable glandular hairs are seen dotted over it. The hairs, when highly magnified, are not unlike toadstools in shape, the top being the glandular part. They are of two sizes, the larger having much longer pedicels, and twice as many cells composing the glands.

Dead and dying insects can be seen on the leaves, many of them washed by rain underneath the incurved margins. Darwin's experiments demonstrate that when bodies yielding nitrogenous substances are placed on or near the margin, it curls slowly over them or pushes them across the leaf. A few hours elapse before the incurvation is noticeable. The experiments further show that the glandular hairs in contact with objects laid on, or caught by, the leaf secrete copiously. When the objects are digestible, the secretion contains a ferment and an acid, and the digested matter is absorbed. Incurvation does not last long, re-expansion being commonly accomplished in about 24 hours. As in Sundew, the roots are but poorly developed.

On the margins of pools examples of the **Marsh Club-rush** (*Eleocharis (Scirpus) palustris*) may be gathered. This species bears very little resemblance to the Sea Club-rush, already described. The stems rise in tufts. They are rather stiff, with two brown basal sheaths, 6 inches or more high, and bearing terminal, spear-shaped, dark-brown spikes, $\frac{1}{3}$ to $\frac{1}{2}$ inch long.

One of the commonest plants in marshy parts is the **Marsh Pennywort** (*Hydrocotyle vulgaris*). Its leaves, being orbicular, peltate, flat, and $\frac{1}{2}$ to 1 inch in diameter, bear a resemblance to coins. They lie near the ground, and cover the slender, prostrate, creeping stems. The flowers are minute, and are hidden by the leaves. It requires some care to assure oneself that they are Umbelliferous, yet such is the case.

The greater part of the area of the Moor consists of drier ground, having its own characteristic vegetation (Plate VII., fig. 1). The most striking plants are, of course, the Heaths. Over great tracts the Heaths are

fungus operates in a manner suggesting not only the substitution of the threads for the root-hairs of the Heath, but an efficient means of exploiting the peaty soil for nutrient substances present there in a form unavailable to the Heath directly. The fungus as a whole, entering into this form of partnership, is termed a **Mycorhiza.** The symbiosis of plants so totally different in structure, and antithetical in respect of nutritional needs, presents a problem of great complexity. A large array of questions spring to one's mind, with reference to the peculiarities of the soil in which such plants grow, the constitution and needs of the plants themselves, and the circumstances which may have led to the compact between the partners.

In some quarters where there is little else than heather, one need not be surprised if he stumbles on the **Eider Duck** (*Somateria mollissima*). Tents Muir is a favourite nesting-ground for the Eider Duck. For some years the bird was scarce there, but after a period of protection the numbers have been greatly increased. Returning in March from their winter quarters, the birds do not commence to nest before the middle of May. Observations show that the same birds return to the same place for several years in succession. While the nests are to be found amongst the heather, they are common enough amongst grassy vegetation also. Conscious of the great privilege he is enjoying, the search for the nest is always a pleasurable exercise to the genuine naturalist. Its whereabouts may often be surmised by the movements of the drake, who is unexpectedly conspicuous against the dark heather, by reason of the white parts of his bulky body. It is a different matter with the duck. One may almost trample on her before she is observed, so closely does her sober colour agree with the greys of her surroundings. An approach can usually be made near enough to photograph her as she sits. Her boldness is attested by the fact that she has been known to endeavour to frighten away a naturalist who feigned fear of her, by rising from her nest and advancing towards him and making an angry sound. Both male and female are strong fliers. When the nest is deliberately left, the eggs are covered up with down, heather, etc. Five eggs are a common number, but more may sometimes be found. The nest (Plate VII., fig. 9) is not fully furnished with its cosy down until all the eggs are laid. A little is added daily from the time the first egg is laid. The amount of down is an indication whether the eggs are "fresh" or not. The colour of the eggs is a bright green when fresh, changing to brown when sat on. The abandoned nests, composed as they are of a large quantity of the grey down, are not difficult to find, if one knows the likely localities to look for them. The nest may be a mile or two from the shore. When the time arrives to proceed to the sea, the young chicks set out at daybreak, and it may take two days to accomplish a march of two miles. They are not accompanied by the male. He disappears from the scene when the eggs are hatched, as if conscious of the fact that his presence would lead to detection of his progeny. The young birds are jet black. When danger arises on the march, they crouch and keep quiet, and the mother flies away. They are so far lacking in the sense of self-protection that they allow themselves to be lifted, without making any effort to escape. The mother and the chicks go to the rocky parts of the shore, where they may be seen swimming about in the lakes, or waddling over the rocks to reach more suitable retreats. Eiders are seen on our coast all the year round.

Many different species of grasses grow in the dry regions of the Moor. One of them, also found on the

Links, deserves more than passing mention, namely, the **Mat-grass** (*Nardus stricta*) (Plate VII., fig. 5). This is an excellent example of a xerophyte. It forms dense tufts or tussocks, the wiry leaves standing close together, not unlike a brush, and the tough, strong roots laying tenacious hold of the dry peaty soil. The inflorescence or ear is also suggestive of drought-resistence. It is distinctly one-sided, and not unlike a feather which has been lying for a time at the mercy of the weather. As the season advances, the Mat-grass assumes a very withered aspect, and is then largely the means of causing the parched appearance of the Moor.

Here and there in drier ground one meets with the **Common Club-moss** (*Lycopodium clavatum*) (Plate VII., fig. 7). The stem is prostrate, and creeps amongst the heather and other vegetation, extending for a number of feet, branching freely, and emitting wiry roots at intervals. The plant is most interesting when it produces its club-shaped spore-bearing cones. They are 1½ inch long, and rise erect, usually in pairs, but sometimes solitary or in threes, on a rigid slender peduncle. If the cones are shaken when ripe, a cloud of yellow dust, composed of spores, flies from them. The powder is familiar to students of acoustics, being used in experiments on sound: as it is highly inflammable, it was utilised formerly in order to produce imitation lightning on the stage.

Another species, the **Fir Club-moss** (*L. Selago*), may be found. It is not possible to mistake this plant for anything else. The short, bent stem bears densely leafy, erect, forked branches, forming a level-topped tuft, 3 to 6 inches in height. The spore-cases or sporangia are not borne in distinct terminal spikes, but amongst the leaves in the uppermost parts of the branches. The sporangia are frequently replaced by little, flattened, leafy bodies which can function as bulbils.

carpet. The woolly mass is composed of long, white hairs, with which the seeds are crowned.

In a few marshy spots one of the prettiest plants imaginable is to be found—the **Bog Pimpernel** (*Anagallis tenella*). This plant is a perennial, with numerous slender creeping stems about 6 inches long. The leaves are small, roundish, and opposite. The elegant funnel-shaped flowers are borne singly in the axils of the leaves on long thread-like stalks. The petals are very pale rose, finely marked with stripes of a deeper tinge. It may be recalled that the other British *Anagallis* is the Scarlet Pimpernel (*A. arvensis*), an interesting annual plant found in cultivated fields.

Growing on the sandy sides of the open ditches which have been cut across the Moor, there is to be found a peculiar little plant called **Flax Seed** or **Allseed** (*Radiola Millegrana* or *R. linoides*). It is a relative of the very similar, but larger, plant of common occurrence in old pastures and on untilled braes, the **Purging Flax** (*Linum catharticum*), and of the more useful Common Flax (*L. usitatissimum*). Our plant is an annual, 1 to 2 inches high, with erect stem, and thread-like branches which fork repeatedly. The flowers are minute and white, with parts in fours.

Two Speedwells are to be found in the ditches and marshes. One, the **Marsh Speedwell** (*Veronica scutellata*), is a perennial with slender, brittle, prostrate stems, and erect flowering-branches. The leaves are linear-lanceolate, entire or slightly toothed. The flowers are pinkish or white, and borne in loose, alternate racemes.

The other species is the **Water Speedwell** (*V. Anagallis*). This is a very much stronger plant. The stems are stout, hollow, succulent, and erect; the leaves oblong-lanceolate, half-clasping, and toothed. The flowers are borne in many-flowered, axillary, paired racemes. The corolla is pale-blue or lilac, with lines of darker colour. It is an annual.

No member of the Buttercup genus is more attractive than the aquatic one, the **Water Crowfoot** (*Ranunculus aquatilis*), when it is grown in a place that suits it. A broad, sluggish stream gives it an opportunity of display, but sometimes it does well in a pool. Such a pool exists at Big-end, a small farmstead on the Moor. When in full flower, the surface of the water is a continuous sheet of white. In the small pool forming the moat round the Water-hen's nest (Plate VII., fig. 6) a few flowers only of the Water Crowfoot appear. The most noteworthy character of this plant is the dimorphism of the leaves, the floating ones being entire, and the submerged ones cut up in a fringe-like fashion,—an undoubted case of adaptation to environment.

Here and there at points on the Moor we meet with a rather insignificant Crucifer, the **Shepherd's Cress** (*Teesdalia nudicaulis*), a plant not unlike a starved Shepherd's Purse. This small annual occurs in dry, sandy places. Its lyrate, pinnatifid leaves form a rosette from which several flower-stems rise, the central one being erect and leafless, and usually not more than 2 to 3 inches high. The flowers are minute and white. The pods are rounded, $\frac{1}{6}$-inch long, and borne in short racemes. While this plant is usually very small on the Moor, it grows to a very much larger size on the sandy cultivated fields on its borders, as, for instance, at the Morton.

A few parts of the Moor are under wood. The most noted plantation is known as the "**Old Fir Park.**" It seems to have derived its name from the presence of a very fine old specimen of the Scots Pine. The illustration of this tree (Plate VII., fig. 2) is taken from Messrs.

Jeffrey and Howie's 'Trees and Shrubs of Fife and Kinross.' It has a massive, clean bole, bearing a large, spreading head, characteristic of old specimens of *Pinus sylvestris*. The great branches now reach at one side almost to the ground. This tree has been for a very long time the home of the Kestrel. I remember visiting it with a few schoolmates many years ago, for the special purpose of studying that bird's habits. Long before the date of that adventure, the late Mr. George Bruce had visited the same place for a like purpose. He says: "On May 7th, 1855, I got two nests on large Scotch fir trees in the 'Old Fir Park' on Tentsmuir, one with two, the other with four eggs, all fresh; and on the 17th of May I got another with five eggs, also fresh, in the same wood." The majority of the trees in the wood are birches.

Passing through the Old Fir Park on 29th May 1909, I saw a considerable company of the Small White Cabbage Butterfly engaged in sipping the honey from the flowers of the Dog Violet. The Butterflies were exceedingly assiduous in their task, and the result would certainly be a fuller yield of seed by the flowers they were flitting amongst. It was a highly pleasurable surprise to happen suddenly—in the charming solitude of that sylvan retreat—on the band of white-winged revellers rejoicing almost passionately in the sweets the lovely purple flowers afforded. It was just in such a spot as this, and with the juice of a violet too, that Oberon amused himself at Titania's expense—

> "I'll watch Titania when she is asleep,
> And drop the liquor of it in her eyes."

PLATE VIII.

FIG.

1. The beach at the Witch Lake.
2. Hartstongue Fern (*Scolopendrium vulgare*).
3. Stigmaria, with roots.
4. Coal seam at the Ladies' Bathing Shelter.
5. Encrinite ossicles, and *Edmondia unioniformis*.
6. Encrinite Bed at the Smugglers' Cave.
7. A, Iron ore; B, Coal: C, Limestone.
8. The Well in the Castle Court-yard.
9. Fossil Plants in shale: A, *Stigmaria;* B, *Calymmatotheca (Sphenopteris);* C, *Calamites*.
10. Part of the Subterranean Passage at the Castle.
11. Rock strata beneath the Kitchen Tower of the Castle.

PLATE VIII.

remains of eleven were found. They lay in the sea-sand overlying the clay, and the graves or trenches, which had been excavated in an east-and-west direction, seem to have followed the seaward dip of the clay. From the appearance of the skeletons, it is almost certain that the sand had been subjected to some shifting by slipping downwards. When excavations were made on the beach, in January 1910, for the foundations of a breakwater at this place, others were found, lying in the line of the wall. They were covered by the clay to the depth of about a foot. The opinion generally accepted is that the skeletons were those of people who had died of plague.

On the sands, between tide-marks, there may be found, without any trouble, weathered pieces of stone with great numbers of minute, cylindrical, white bodies projecting from their surface (Plate VIII., fig. 5). Their occurrence on the beach leads one naturally to conjecture that the rock from which they had been broken may be near at hand. A brief search amongst the strata on the shore discloses the bed jutting from the sand close to the outer corner of the concrete wall on the south edge of the cove (Plate VIII., fig. 1). The stratum can be traced easily as its outcrop runs eastward, parallel with, and a few yards out from, the cliff base, passing the Smugglers' Cave (Plate VIII., fig. 6) and the Baths. The dip of the rocks here is to the south, and about 15 degrees, the strike being almost due east-and-west. The existence of the bed has long been known, and it is named the **Encrinite-Bed.**

The Encrinite-Bed forms one of the most interesting geological features which our beach presents to the student. It has been carefully traced westward for a long distance inland, and it reappears at irregular intervals eastward on the coast. Many species of fossils present in it have been identified by experts, but it will serve our purpose if we note a few of the commonest ones. The Encrinites were members of a section of the Star-fish family (Echinodermata), termed the Crinoidea. Instead of being free, like the Star-fishes, to wander at will, they were "rooted" to the bottom of the sea by stalks of considerable length. A radiate animal, like a flower, was borne at the top,—hence the Crinoids have come to be called "Stone-lilies." The stalks were constructed of short joints—the ossicles; and it is these which, separated, or still united together in shorter or longer pieces, form the greater part of the rock mass. Short portions of the stalks intact are illustrated in the inset of fig. 5. The ossicles lie in what was originally mud, but is now an argillaceous limestone.

Light is thrown on the conditions under which the Encrinites lived, by the presence of fossils of shell-fish in the same stratum. The single shell, *Edmondia unioniformis*, seen in the centre of fig. 5, is one of the Lamellibranch Mollusca, the group to which the Mussel and Cockle of the present day belong. There is evidence that certain of the old-time shell-fish lived in a gregarious manner like the living Molluscs mentioned. The mud in which they lived would be carried down by a river which made its way through groves of trees, whose remains ages afterwards formed coal. The mud would be borne out to sea, and at a certain depth the Encrinites would find a home on it. There is no doubt, from what is known of the living relatives of the Encrinites, that, although the adults were anchored, the youngsters would be swimmers and rovers, and so spread the colonies.

A shell (*Streptorhynchus (Orthotetes) crenistria*), appearing in great abundance in certain parts of the beds, but not illustrated, recalls the Scallop in its shape and sculpturing, being characterised by having a straight hinge, and numerous fine striæ arranged like an open fan and crossed by concentric lines. Although bearing a general resemblance to the Lamellibranch bivalves, it differed profoundly from them in structure. The class to which it belonged is characterised by the shells being unequal in size, dorsal and ventral—not right and left—in position, and by possessing spirally-wound oval "arms," fringed with tentacles, and functioning as respiratory organs. To those two characters are due respectively the trivial and the technical names of the class,—Lamp-shells, and Brachiopoda. The molluscan features of the Brachiopoda are superficial, the relationship of the Brachiopoda and Mollusca proper being remote.

The **Brachiopods** are an exceedingly old family. They abounded in the earliest seas of which geology has record, and having attained their zenith as a race long before the Carboniferous epoch, they have since steadily declined. Remarkable to relate, however, one genus, *Lingula*, has refused to be influenced by "the long result of Time," and has kept its pedigree pure from the Cambrian era up to the present hour. On the contrary, the Lamellibranchs, although comparatively abundant in the Coal Period, have proved themselves not only fitted to survive, but to advance, and they are now more numerous and more highly organised than at any previous epoch.

Objects like scraps of torn lace may be seen in hundreds associated with the Encrinites and shells. Their reticulated structure leads one at once to associate them with the **Polyzoa** (Bryozoa) or Sea-Mats. They have been termed "Lace-corals," and one of the commonest of them is *Fenestella*. The zoarium—as the entire netted colonial structure is called—is preserved through having been originally calcareous. It is fan-shaped, and composed of the cells or chambers in which the polypides, or individual animals of the colony, lived. In existing forms the

up, their fracture displays a silvery mass of iron ore (mainly Marcasite) (Plate VIII., fig. 7 A). A note of interest with reference to the occurrence of ironstone here, taken from the Town Council Minutes, is given by Dr. Hay Fleming in his brochure on the Charters concerning the Mussel-scalps: "On the 17th July 1766, the ironstones among the rocks between the East and West Sands were let for a year at 23s stg." Referring to the same, Lyon, in his smaller History of St. Andrews (1838), says: "Near to where the old 'Butts' were situated, there are several alternate strata of clay and ironstone, the latter containing about 30 per cent. of pure iron. Pieces of these are washed out, and rolled about by the sea; and used to be collected, and shipped to the Carron or other iron works."

Half-way between the Step Rock and the Baths, evidence of an extensive fall of rock from the cliff face is seen. A large body of rock, which had been undermined by the sea, fell on 12th August 1907. The broken masses are being rapidly disintegrated by the waves, and a heap of soft sand has been formed. Quarrying operations are not permitted in that region nowadays, but the following two records show that concessions to quarry were given in the past by the Town Council: "On the 23rd July 1817, Major Cameron was allowed to quarry stones from the rocks to the westward of the Baths;" and, "On the 12th March 1818, Alex. Couper was allowed to quarry stones from the rocks near the Witch Lake."

Near the Baths, a ladies' bathing-place,—at the institution of which, the Town Council granted by charter to a private individual, in 1810, a considerable part of the foreshore,—we see soft blue shale in the vicinity of the Encrinite-Bed, perforated by auger-like holes, large enough to admit the finger. In many, an inmate is visible within the tube. When disturbed, its long, wrinkled, brownish siphon contracts rapidly, and a jet of water is ejected. By picking the shale carefully away, the creature can be removed intact. The body is encased in two valves. We have already become familiar with them, having gathered them on the West Sands. They are those of **Pholas crispata** (see Plate III., figs. 5 and 6). The mollusc has obviously very little room to move in its burrow; and it must of necessity be imprisoned there, because the lower part occupied by it is larger than the mouth. While the extensile siphon projects from the upper (posterior) gape of the shell, a remarkable shield- or sucker-shaped organ—the foot—protrudes slightly from the lower (anterior) gape. Besides the two large valves, there exists close to the hinge in the lower gape a three-cornered testaceous plate, known as the accessory valve.

For a long period the question of the method employed by Pholas in boring its burrow has been under discussion, and no satisfactory explanation has been arrived at. There seems no serious difficulty in the task required of the mollusc when the rock is soft shale like that at the Baths; but it can also make a home for itself in very hard rocks. Various theories have been advanced, involving the purely mechanical means of friction by the shell, the presence of silicious particles, etc.; and chemical ones, by the secretion of solvents; but all fail in one respect or another.

Towards Castlecliffe, we pass over sandstone strata richly charged with root-like fossils of a kind met with almost everywhere in the sandstones and shales of our coast. They are characterised by being dotted all over with circular pits arranged in a regular spiral fashion. The presence of these indentations has led to the fossils being named **Stigmaria.** Specimens are met with which show that the scars are the points where appendages, bearing all the appearance of roots, had been attached (Plate VIII., fig. 3). The appendages are seen to pass at nearly right-angles from the pitted axis into the soil now compacted into sandstone. Near the bottom of the cliffs, there is a thin stratum of shale in which examples of Stigmaria are seen exhibiting an axial cylinder outlined in carbonaceous matter. The fossils in this neighbourhood are little better than mere casts in sandstone; but, in some parts of the country, the Stigmariæ are to be found thoroughly petrified, the mineral matter in a state of solution having permeated the tissue and taken its place so completely as to preserve the microscopic structure. When microscopic sections can be studied, much light is shed on the affinities of the Stigmaria with its present-day relatives. Pieces of the fossil are found which show that when branching took place, it was dichotomous, the two branches being of equal size. It has been established that Stigmaria is the underground part of plants of two closely related genera, found fossilised in great abundance, viz., *Lepidodendron* and *Sigillaria*. These plants have been identified as members of the same group as our **Club-mosses**, the Lycopodiaceæ. In certain of these, *e.g.*, Selaginella, the roots are borne on peculiar structures, which some authorities regard as branches specially modified for the purpose, and hence called **rhizophores.** It is usual to regard the Stigmariæ as rhizophores, and the appendages as roots; there is no serious inaccuracy, however, in calling them respectively roots and rootlets. One striking distinction is observable between the rhizophores of the modern Lycopods and the fossils we are discussing, viz., the enormously greater size of the fossil forms. The Lycopods which lived in the Coal Period were in many cases large trees, the tallest being perhaps 100 feet in height, whereas those of our moors are, by comparison,

characteristic of the fossil Horsetails. It has been pointed out that these familiar characters, which remind us of the exterior of the stem of our living Horsetails, are in reality casts of the interior of the woody cylinder of the fossilised stem. Calymmatotheca, long considered a fern, is now recognised as belonging to a group having affinity with the Ferns on the one hand and the Cycads on the other, thus forming a connecting-link between those two great groups.

A neighbouring ledge is the outcrop of a bed of limestone of quite different character from the Encrinite-Bed, which runs to sea beyond the Baths, and is accordingly sunk deep underneath the bed at the Castle. This bed is understood to correspond with the **Myalina Limestone-bed** which crops out on the shore to the east, and is specially noteworthy a short distance beyond the Rock and Spindle (see Plate XII., fig. 1). A portion of the limestone from the Castle bed is illustrated in Plate VIII., fig. 7 c. The rock is very hard, with the shells clearly visible in its mass.

A little farther to the south, in front of the Ladies' Bathing Shelter, a thin seam of coal is exposed, close to the level of the sands (Plate VIII., fig. 4). This seam is of special interest, because of its connection with the so-called **Subterranean Passage** now to be described.

In April 1879, a little one-storeyed house which stood opposite the Castle, at the north-east corner of South Castle Street, was pulled down, previous to the building of the new house now occupying the site. After the removal of the shallow foundation-courses of the old house, difficulty was experienced in finding firm ground on which to build the north gable of the new house, and it became necessary to dig down until a suitable bed was reached. At about 7 feet from the surface the workman's shovel suddenly pierced a cavity, and a considerable quantity of earth slipped into it. Further excavation disclosed the entrance to an arched chamber cut in the rock.

The story of the exploration of what was found to be a very remarkable passage is, for several reasons, well worth recounting. I have endeavoured to refresh my memory by getting first-hand information on the subject from the most reliable sources still available. On my first visit to the place, I saw nothing more exciting than a few boys throwing flaming newspapers into the pit. Returning later, with the intention of entering the passage, I was informed by bystanders that two natives of St. Andrews, still resident in the city, had, with a small party, succeeded in passing through and making an opening at the other end. I was thus led to believe that they were the first to explore the passage. Along with others, I then made a journey through it. This was by no means a pleasant experience. In a somewhat hurried note descriptive of the passage, contributed to the 'St. Andrews Citizen' of 19th April 1879, I gave the above gentlemen the credit I thought they deserved. A newspaper controversy ensued, in which it was stated that the exploration had been first accomplished by two lads, John Dowie and John Lumsden, and that they penetrated the whole length of the passage, but returned without finding any outlet or making one. It was thus left to the others mentioned to locate the inner end and make communication with the outer air there.

The point of most interest raised in the discussion was whether Messrs. Dowie and Lumsden, in their journey through the passage, increased the size of the hole through which, after further enlargement, the visitor now passes in comparative comfort by means of a ladder (Plate VIII., fig. 10). This is a crucial point, for on it depends the question whether the place can or cannot be regarded as a passage at all. A correspondent who took the part of the first explorers, and doubtless was instructed by them, stated that when they reached the hole in the roof they found it too small even to admit their heads, and they got a pick and made it large enough to let them through. A champion of the other explorers thereupon insisted that no pick marks round the hole were observed by them. In a rejoinder to this, regarding Messrs. Dowie and Lumsden's claims, explicit statements to the following effect were made: The marks of the pick could still be observed. When the lads first saw the hole its edge was cup-shaped, and not more than 6 inches in diameter at the bottom. There could be no mistake as to the size, and as to the edge being solid rock. They tried to put a shovel up through the hole, but this means being ineffectual, they got a pick and wrought with it for nearly half an hour before the orifice was rendered large enough to enable them to pass through. Owing to its cupped shape, there was no great thickness of rock to be removed.

If the aperture was originally as small as stated, there could be no passage for anyone. Its dimensions before it was enlarged to its present size are stated to have been 13 inches by 15, thus permitting an ordinary-sized person to wriggle through if his arms were raised above his head,—a condition of affairs that led Dr. Hay Fleming to remark at the time that "extra stout people might complacently regard their being debarred as one of the penalties of *greatness*."

It is now impossible to decide whether the earth which so far filled the wide stairway and the lower chamber had all slipped in naturally, or whether more or less of it had been thrown in. There was probably about 2 feet of earth in the chamber underneath the orifice, and the journey to that chamber had to be made by creeping, if not gliding, on the earth. A very considerable quantity

south, and the entire length, including the bendings, is about 50 yards. The entrance as it exists now was made for the convenience of visitors some time after the discovery of the passage, and the steps at the door were cut then. The accompanying plan and section of the passage (Plate VIII. A), while not absolutely accurate in small details, are sufficiently exact to give a good idea of the shape and levels.

Entering at the Castle end, the visitor passes down a burrow having an average height of 4 feet. A few yards down on the right (west side) is found an excavation which could not have served any other purpose than a seat. This is almost opposite the entrance of a branch of the passage which runs to the left (east side) in the direction of the sea. A short distance down this branch a pouch, evidently the beginning of another projected branch, is passed on the right, and a few yards farther on the main branch itself ends blindly. Returning to the open passage, we find, close to the mouth of the branch, a check which has every appearance of having been made to receive a barricade or a door—4 feet wide, and 3 feet 6 inches high—to cut off exit from below. Thereafter the burrow bends in an easy curve to the right. At the foot of the burrow a step 15 inches high occurs, and, beyond it, is a fairly roomy part, 5 feet 7 inches in height, leading to the left. At the far end of this chamber a hole is pierced in the floor, and on the right side of the hole there is a recess of considerable size. Standing in this recess, one feels that it had been made either to enable defenders to keep guard over the hole, or to admit of more convenient lowering of material of some kind through it. Reference has already been made to the opinions held regarding the original size of the hole. Descending the ladder, we find ourselves in a spacious chamber, 14 feet wide and 7 feet high. The height at

Subterranean Passage at the Castle.

the rock. The part of the passage leading down from the Castle dips at an angle of 15 degrees. The floor of the great chamber is 22 feet 5 inches beneath the level of the floor of the passage at the entrance door, or 30 feet beneath the level of the turf over the door, and 44 feet 8 inches beneath the level of the grating. The top step, on which the lowest course of the wall is set, is 19 feet 9 inches beneath the grating. The roof of the passage is there 7 feet 9 inches high, and the width of the wall where it blocks the passage is 8 feet 9 inches. The flight of steps descends 25 feet from the top step bearing the wall.

If any apology is needed for the introduction of this lengthened description of a place of greater interest to the antiquarian than the student of Nature, the excuse may be offered that the latter will find it instructive to study the strata through which the passage has been cut. The thin coal seam already referred to as visible on the beach has clearly had much to do with the form the passage has taken. The seam is found immediately under the roof of the upper passage and its branch, through their entire length, and it is obvious that it had been followed as a means of giving an easy opening for excavation. The seam is lost to sight in the wall above the hole, and it reappears in the roof of the large chamber at the distant buttresses, whence sloping down the walls, it is finally lost on the face of the seventh step of the great stair.

Twenty-two years before the discovery of the Passage, the Castle ruins were cleared of great accumulations of earth and rubbish. In the centre of the court-yard the removal of a mound of earth exposed a deep well (Plate VIII., fig. 8). Nobody knows how long the well had lain hidden. The top part of the well is formed of built masonry, but the lower part is cut from the solid rock. The weathering of the sandstone in the well is very considerable, and must have been in progress for a long time prior to the closing of the well. The ledges are now covered thickly with the **Hartstongue Fern** (*Scolopendrium vulgare*), in the very highest vigour. I have not been able to find out how long it was after the reopening of the well that the ferns were observed growing there. It is a matter of much interest to know whether the spores of this Fern could lie dormant for centuries. It seems very natural to suppose that the well would be the home of the Fern when the Castle was in its pomp. This species is certainly a native of the district, although one has to go some distance to see it "at home" elsewhere than in the Castle well.

The Hartstongue differs from most of our native ferns in having strap-shaped undivided leaves (Plate VIII., fig. 2). The sporangia are borne in linear masses, which are placed like parallel ribs on the underside of the leaves. The broad luxuriant foliage of this dweller in a damp sunless place contrasts in a striking manner with the small, hard, deeply-divided foliage of the Wall-rue Spleenwort (see Plate II., fig. 9), which so often is found basking on the sunny side of ruined walls.

Chapter IX.

From the Castle to the Harbour.

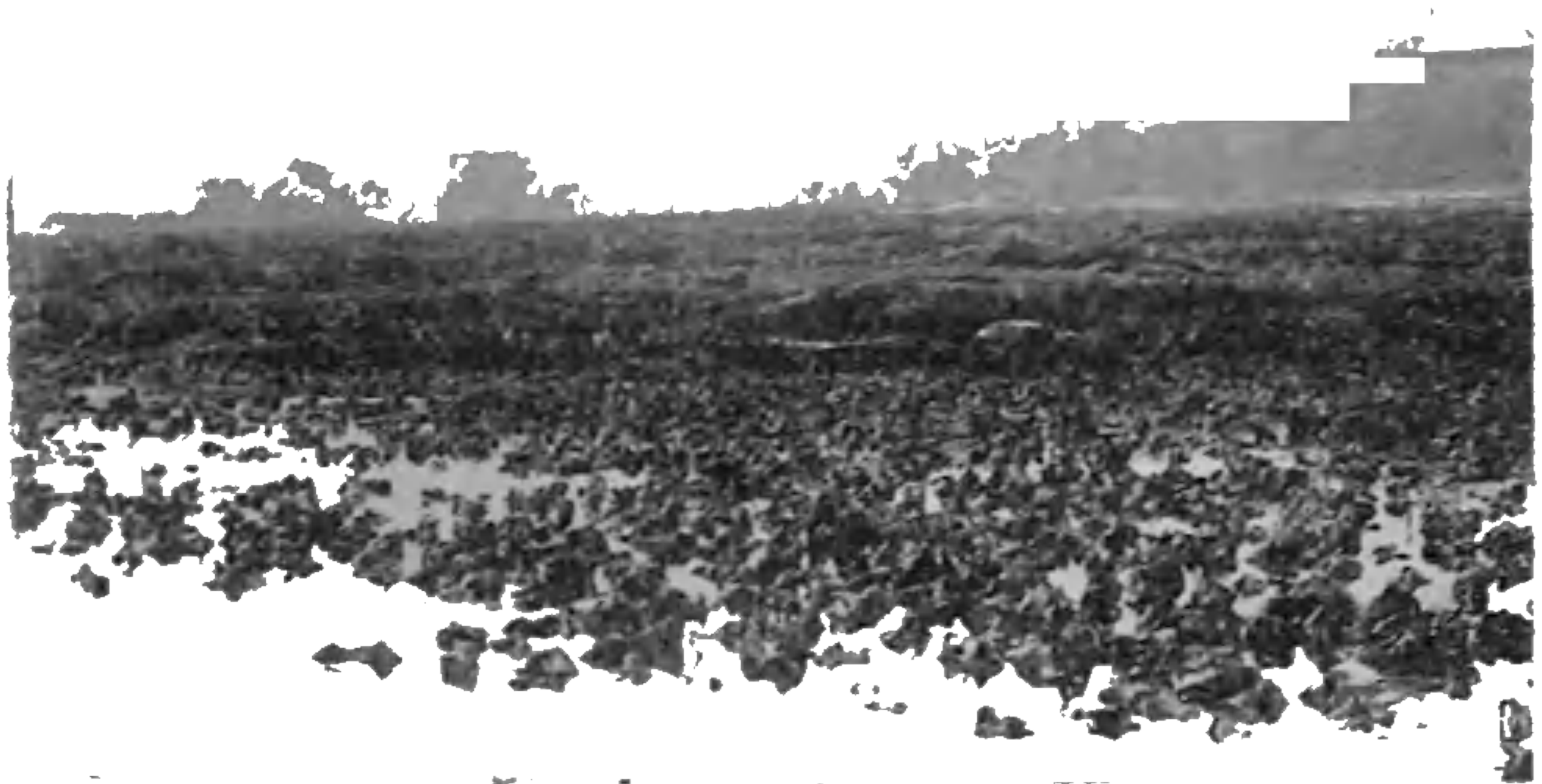
The rocks to the east of the Castle lie in long parallel chains, exposed at low spring tides to a distance of several hundred yards. Here, as in the foreshore between the Step Rock and the Castle, the hardest rocks have remained as ledges, while the long straight channels or reaches have been scooped out of the softer strata to form what are locally called lakes. One of the lakes, that running out from the north edge of the Ladies' Bathing-pond, is known as the **Hind Lake.** The word Hind means a haven. It is to this lake that the fishing-boats go when the water is too low to admit of their entrance into the harbour. It is quite certain that it would be a place of landing at low-water in old times. A deep, natural, dock-like basin, reached by an entrance of its own, exists on the south side of the extremity of the Hind Lake. The footpath to the point of embarkation is not a very satisfactory one, although fairly well worn by the feet of generations of fisherfolk. The third lake to the south of the Hind Lake is called the **Broad Hind.**

Much of the highest interest to naturalists may be seen at the Hinds. The best method of exploring the region is to go at a spring tide, and follow the retreating water out during the last hour of the ebb. Only those

PLATE IX.

FIG.

1. Laminariæ exposed at low water.
2. *Hydrolapathum (Delesseria) sanguineum.*
3. Rock ledge with: A, Horse Mussel; B, Hermit Crab; C, Grantia; D, Halichondria.
4. Deformed Cross-fish (*Asterias rubens*).
5. Egg-urchin (*Echinus esculentus*).
6. Fucus, bearing tubes of Spirorbis.
7. *Plocamium coccineum.*
8. *Corallina officinalis*, with *Leathesia* attached to it.
9. Brittle-Star (*Ophiothrix fragilis*).
10. The Long Pier, with Buck's-horn Plantain (*Plantago Coronopus*) growing on it.
11. Porpoise lying on the beach.

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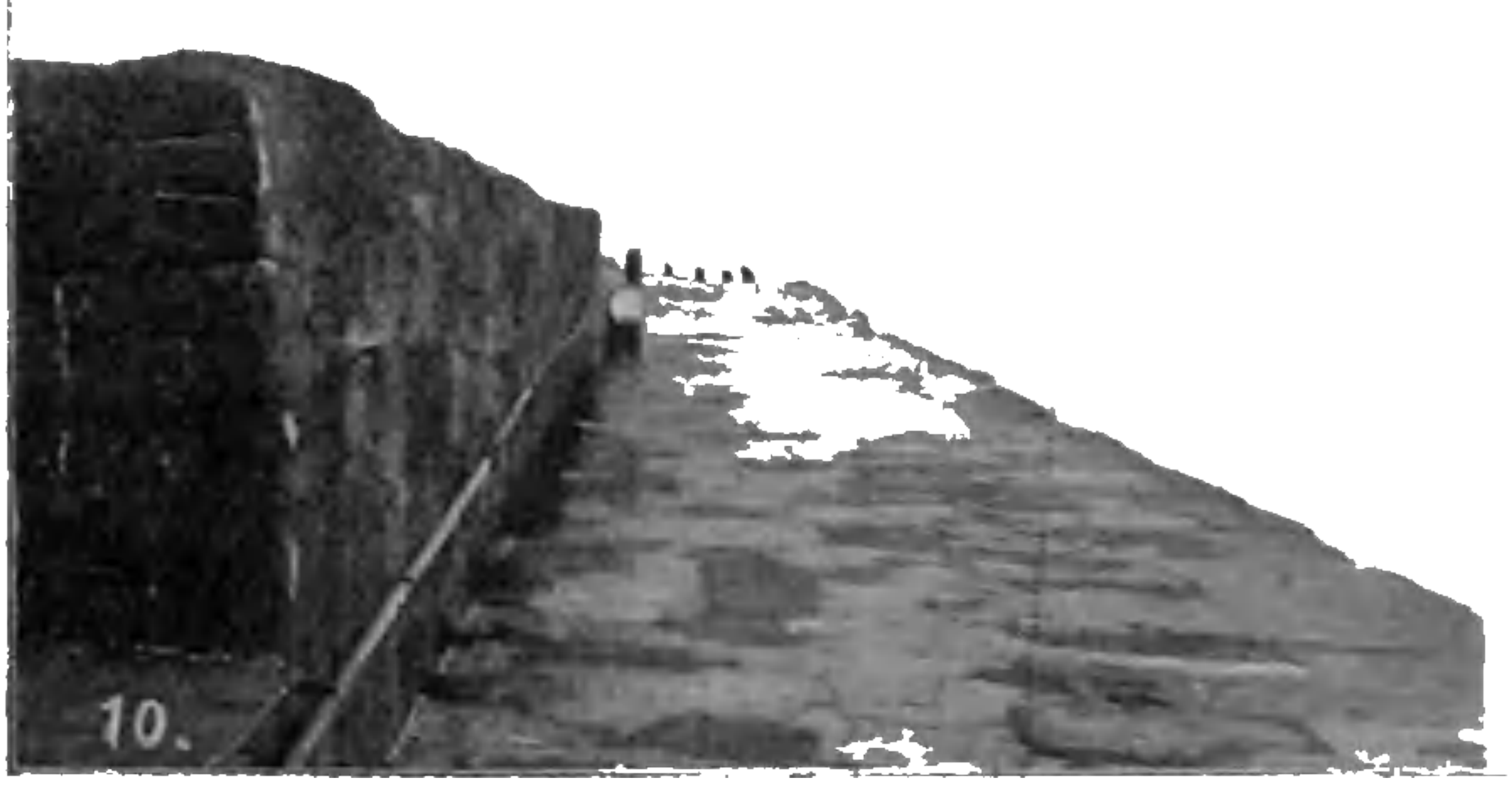

ashore on the part of the beach we are studying is not free spoil, as on other parts of the beach, but is let by the Town for what it will fetch.

Colour, although an unreliable character in most plants, has been found sufficiently diagnostic to be employed in distinguishing the great groups or classes of Seaweeds,—viz., the **Olive-brown** (*Phæophyceæ*), the **Green** (*Chlorophyceæ*), and the **Red Seaweeds** (*Rhodophyceæ* or *Florideæ*). Although the Brown and Red Algæ seem devoid of green colouring-matter, it is easy to demonstrate that the chlorophyll or leaf-green, characteristic of vegetation in general, is in them merely masked by the brown or red substances respectively. These substances can be extracted by immersing the plants in fresh water, and the insoluble green colour is thus rendered visible. The colours in question have been observed to be associated in a fairly well-defined manner with certain areas in the regional distribution of the Algæ. As a general rule the seaweeds nearest the shore are green; between tide-marks they are olive-brown; and at the outer limit of algal life red. Where red seaweeds occur between the tide-marks they are found under the shelter of the brown ones, or in shady places. The pigments are obviously present to assist the chlorophyll in adapting itself to carry out its work of nutrition in a varying supply of sunlight.

In the same family as the Tangles, and growing in the same region, we find *Alaria esculenta*, called in some localities Bladderlocks or Hen-ware. Its frond is furnished with a distinct midrib, and the stem bears small leaflets. This seaweed used to be considered edible, the part eaten being the midrib.

A second relative of the Tangles, but of an entirely different form, is *Chorda filum*, sometimes called **Sea-laces.** This remarkable alga consists of thin, cylindrical, olive-green cords, as much as 20 feet or more in length, covered with minute hairs, and very slippery to the touch. It is sometimes seen lying in great coils on the beach after storms.

In another family, that including the familiar genus *Fucus*, there occurs, attached to the rocks exposed at low water at spring tides, a seaweed unlike any other we will meet, in possessing a cup- or funnel-shaped frond or thallus, 1 to 1½ inch in diameter. The button-like cups are very deep olive-brown, and are often found in large numbers side by side. From the centre of the cup there grow one or more very long, thong-like, forking shoots which constitute the fructifications. This alga is named **Sea Thongs** (*Himanthalea lorea*).

Nearer the shore we find the rocks dangerous to walk on, being carpeted with brown seaweeds. Certain of them are very familiar by reason of their bladder-like floats, which, when trampled on, explode with a fairly loud report. In one of them, the **Common Bladder-wrack** (*Fucus vesiculosus*) (Plate IX., fig. 6), the frond is narrow, flat, and dichotomous, with a well-defined midrib. The air-vessels when present are usually paired, and placed on each side of the midrib. This species grows in masses between tide-marks. The air-vessels are usually absent from plants growing near high-water mark.

Another species, *Fucus serratus*, occurs in great abundance in company with the above, but is disinclined to go farther shorewards than the line of half-tide. It is easily distinguished by the serrated margins of the fronds and the absence of air-vessels. The fertile parts, called receptacles, are terminal, and the same width as the part of the frond which bears them.

A third species, *Pelvetia (Fucus) canaliculata*, is found just below high-water mark, but also on rocks that are merely moistened by the spray. It must very often remain dry for several days, but it is not incommoded thereby. The fronds are linear, repeatedly forked, with a deep groove or channel along one side. No air-vessels are present. The receptacles form swellings at the ends of some of the branches, and commonly occur in pairs.

In the same family is the species now called *Ascophyllum nodosum*, formerly *Fucus nodosus*. This species prefers to occupy a zone farther out from high-water mark than its allies. The thallus is linear, without a midrib, branched, often 3 or 4 feet long, and bearing large, oval air-vessels, placed singly at distant intervals.

The four seaweeds last described are said to be relished by cattle. Another use was found at one time for the seaweeds of our rocks. In the 'Statistical Account of Scotland' (1794) the following reference occurs under the Parish of St. Andrews: "The sea-rocks in this parish are covered with the common weed, which used formerly to be cut every third year, and burnt for kelp. The demand for this article seems to be diminished; as for several years past, the Corporation of St. Andrews have not been able to get their sea-weed let to any undertaker."

The same family also includes *Halidrys siliquosa*. In habit this species differs from its relatives just described in never being exposed to the atmosphere. It is found in pools between tide-marks. It can at once be recognised by its pod-like air-vessels, which are linear-lanceolate, stalked, pointed, and divided transversely by dissepiments.

Before leaving the Bladder-wrack family it is desirable to make a few remarks on the **mode of fertilisation** obtaining in it. Besides the floats or air-vessels, other inflated bodies, as already indicated, occur at certain periods of the year. These inflations are not due to the presence of gas, but to tissue associated with the reproductive elements. The swellings are dotted over

at the base, and becomes widened and compressed upwards, dividing ultimately into flat, forked segments, of very variable breadth. The height is from 2 to 6 inches. The colour is purplish-red when the plants grow in the shade, but it becomes green or yellowish when they are exposed to light. This seaweed is well known as the source of a palatable and nutritious comestible. To preserve it for table use, it is washed in fresh water and dried. It will keep for an indefinite time in the dried state. When boiled it forms a thick jelly.

Closely allied to the Chondrus, and growing in the same region, usually in greater abundance, is the alga named *Gigartina mamillosa*. It bears a good deal of resemblance to the former species, but is distinguished at once by the presence of numerous small tubercles on the surface of the fronds. It can be employed for the same purposes as the Carrageen.

A seaweed very well known for its edible qualities is **Dulse** (*Rhodymenia palmata*). It occurs in tufts on rocks and on the stems of Tangles, etc., in abundance. In the commonest form the short stem bears a number of flat, wedge-shaped fronds, with the extremities notched, and the segments rounded. The length of the frond is usually 3 to 4 inches. Dulse seems to be much less in favour in our neighbourhood now than in days gone-by. It is eaten raw.

Related to Rhodymenia are three very pretty red seaweeds—*Chylocladia (Lomentaria) articulata*, *Plocamium coccineum*, and *Hydrolapathum sanguineum (Delesseria sanguinea)*. All three are well worthy of mention. The first appears in tufts of forking branches, which are constricted to form short, slightly swollen, translucent joints, filled with gelatinous fluid. When specimens are dried, and fixed by pressure to paper, it is difficult to believe that they are not coloured drawings. Plocamium presents quite a different structure. It is one of the favourites with those who use seaweeds for ornamental purposes. When dried and pressed its beautiful red colour is retained. Its fronds (Plate IX., fig. 7) are dendritic and feathery. A distinguishing character is seen under the lens, the branchlets bearing on their upper edges three or four ramuli or teeth in a comb-like series. Hydrolapathum is also a great favourite for decorative work (Plate IX., fig. 2). It is at its best in the early part of summer. The fronds are leaf-like, lanceolate, flat, membranaceous, and pinkish-crimson. The midrib is strong, and the nervures conspicuous. In older specimens the margins are undulate. In winter the fronds become ragged, and reduced almost to the midrib, the fructifications being produced at that period.

In a closely related family of Florideæ are the following: *Delesseria sinuosa* and *D. alata*. The former resembles *Hydrolapathum sanguineum* in general form, but the margins of the fronds are sinuate or pinnatifid. In *D. alata* the fronds remind one of those of Plocamium, but the branches are flat, and consist of a midrib, which is winged with a very narrow membrane.

A handsome, irregularly branched, feathery alga, *Ptilota plumosa*, is found attached to the stems of *Laminaria digitata*.

An exceedingly common species, *Laurencia pinnatifida*, by some called the **Pepper Dulse**, is found on the rocks from high-water mark outwards, extending even into deep water. Its form and colour vary with the positions the plants occupy. The fronds are compressed, solid, cartilaginous; the divisions distichous, tripinnatifid, alternate, and obtuse. The tufts near high-water mark may not be more than an inch in height, and there they have a curled appearance.

Attached in large tufts to *Ascophyllum nodosum*, and sometimes in such abundance as to clothe its host almost completely, is the familiar *Polysiphonia fastigiata*. It differs from all the Red Seaweeds we have hitherto studied in being composed of cylindrical filaments, no thicker than fine threads. Under the microscope the branches are seen to be jointed, and composed of elongated cells in regular tiers, enclosing in each tier a central cell of the same length.

A species of somewhat similar appearance, but of more delicate structure, is *Ceramium rubrum*. It grows on rocks, and also on other algæ, in pools. It differs from Polysiphonia in presenting a much more distinctly jointed appearance, each articulation being covered with a girdle of small, coloured cells. The apices of the branchlets are incurved or hooked.

An alga of an entirely different aspect is the **Purple Laver** or Sloke (*Porphyra laciniata*). It occurs on the rocks within tide-marks. The frond forms a flat, exceedingly thin, purple sheet, the margins of which are wavy and plaited. This plant is used as a table dainty, being gathered in winter for the purpose. It is cooked until it is reduced to a pulp, and is then flavoured with lemon juice.

Yet another very distinct type of alga is to be noted in the **Common Coralline** (*Corallina officinalis*) (Plate IX., fig. 8). It occurs in pools over the whole littoral zone. The most luxuriant specimens are found near low-water mark. It grows in densely tufted patches arising from a spreading, limy base. The fronds are filiform, articulated, and encrusted with a calcareous deposit. When the plant dies, and is exposed on the shore, it becomes white, brittle, and coral-like.

It is interesting to find that the Coralline is often used as a host to which smaller algæ of a different group attach themselves. The illustration of the Coralline

one of the most beautiful, when seen in the depths of a clear pool in contrast with the red species there.

In the course of our collecting seaweeds we are sure to have been tempted constantly to divert our attention to the zoology of the ledges and the rock-pools. From the "Laminarian region" to the shore there is a succession of animal life, bewildering in its variety and absorbing in its interest.

Under the ledges we find hanging downwards flat, white objects, not unlike what would result from pressing firmly small oval pellets of putty between the finger and thumb. These are the sponge, *Grantia compressa* (Plate IX., fig. 3 c). They will be found to have two walls enclosing a cavity, with a large aperture at the free extremity. The microscope discloses the fact that the walls are pierced by numberless tubes, and that these are lined with cilia which, when in action, cause the water to pass inwards, whilst others lining the general cavity drive the water to the outside by way of the terminal aperture. The walls are strengthened by calcareous spicules of two forms, those in the general framework having three sharp-pointed arms radiating from a common centre, while the peripheral ones are club-shaped.

A substance somewhat similar to the flesh of Grantia is seen covering considerable parts of the damp rock (Plate IX., fig. 3 D). The layer is greenish-yellow, and not unlike a piece of a contour-map of mountainous country, by reason of the eminences which rise from the general surface. Each eminence is pierced by an aperture at its apex. This is the **Crumb-of-Bread Sponge** (*Halichondria panicea*). If covered with shallow water the use of the apertures is rendered apparent, outgoing currents from the craters of the miniature volcanoes being quite noticeable. The spicules of this sponge are needle-shaped and silicious, and the flesh is somewhat tough, in both respects resembling its relative, the Mermaid's Glove (*Chalina*) (see Plate III., fig. 14).

In the rock-pools well out one sees groups of a large **Sea Anemone** (*Tealia crassicornis*). When the tentacles of this Sea Anemone are extended they bear a very marked resemblance to some of the Passion-flowers which possess a highly-coloured corona. Almost everywhere amongst the rocks the less attractive blood-red and much smaller Sea Anemone (*Actinia mesembryanthemum*) occurs. The Anemones have the remarkable power of paralysing their prey by means of microscopic stinging weapons. The coral-builders belong to the same family.

Delicate Hydroid Zoophytes are met with in plenty attached to seaweeds and other objects. An example was observed attached to the narrow end of a Horse Mussel (Plate IX., fig. 3 A). A very common one is *Sertularia pumila*. One might imagine that this delicate object was a bleached seaweed. The lens, as previously suggested, shows that the branches bear a symmetrical series of sessile, flask-shaped cups, in opposite pairs. If the specimen is fresh, each cup will be seen to contain a polyp which can protrude itself beyond the edge. When expanded the mouth is encircled by radiating tentacles. Each polyp is connected at its base to a central axis composed of living substance. In Sertularia the generative buds are borne in special bag-like vesicles. In certain other Hydroid Zoophytes, for instance, Obelia —a form with stalked cups—also plentiful on our coast, reproduction is effected by medusa-buds which, in the shape of minute jelly-fish, are liberated from the colony and swim freely about.

Deformed Cross-fish are of common occurrence (Plate IX., fig. 4), the deformity being often due to the partial renewal of lost rays.

A Star-fish of very different form from the Common

Cross-fish is to be found in considerable numbers under stones. This species (Plate IX., fig. 9) is a skeleton compared with the Cross-fish, but with its loss of bulk it has gained greater freedom of movement. Its general colour is a greenish-brown. The limbs are long, and very narrow, radiating from a small central disc. They are very thickly beset with short, stiff spines. Tube-feet are present, but peregrination is accomplished by the wriggling of the limbs. If lifted quickly or carelessly this Star-fish is found to be very brittle, and may readily part with a limb or two. It is well named the **Brittle Star** (*Ophiothrix fragilis*). A species even more substantially built than the Cross-fish, but smaller, and with a smoother dorsal surface, coloured dark purple, is common enough. It is named *Cribrella oculata.*

The **Common Sun-star** (*Solaster papposus*) is to be met with. It is particularly interesting on account of its non-adherence to the five-rayed symmetry, the number of its rays being twelve or thirteen. Usually the disc is red, and the rays paler, tipped with red.

The **Egg-urchin** (*Echinus esculentus*) (Plate IX., fig. 5) occurs sparingly. Its dental apparatus, called "Aristotle's lantern," is an object which excites admiration in respect of both design and construction.

The wealth of animal life discovered by turning over the stones in the pools is somewhat embarrassing to the tyro. One of the commonest of the creatures found attached to the underside of the stones is the Scale-backed Annelid (*Harmathoë*). This worm is flattened, and its back is covered with scales, laid like slates on a roof. It is nearly related to the Sea-mouse (see Plate III., fig. 8), whose scales, however, are hidden from sight under a felted membrane. Other Annelids are to be found by dislodging the "roots" of Laminariæ. There are some which provide their own shelter. One of them, *Serpula*

the rocks. An occasional dwarfed example of the Horse Mussel (Plate IX., fig. 3 A) is to be found firmly attached in some sheltered nook. In younger specimens the valves are clothed in part with short filaments.

Peculiar molluscs, the Chitons, are seen in abundance adhering like limpets to the underside of stones. They differ from the Limpet in being elongated, and protected by a dorsal armour of eight transverse, overlapping plates, in place of a simple shell. The commonest species is *Chiton cinereus*. It is very variable in colour. The Chitons in their structure suggest a connection between the Mollusca and certain families of worms.

The **Limpet** (*Patella vulgata*) is perhaps the most familiar of all the shore molluscs. We cannot but be struck with the dimensions which some of the specimens attain, those with a diameter of 2¼ inches being common enough. It is interesting to note that in course of time the ribs of the shell become worn down until the surface is fairly smooth. As the shell becomes thin the mollusc strengthens it inside by a deposit of nacreous material. The Limpet forms a shallow excavation in the rock to which it returns after its short foraging expeditions. Its lingual ribbon, with which it rasps the seaweeds, etc., that form its food, consists of a strong muscular band bearing a very large number of teeth.

Periwinkles (*Littorina littorea*) are very plentiful, and so are their relatives, *L. littoralis (L. obtusata)*. One of the latter surprises us by suddenly raising itself from its bed and moving off at a high speed,—a quite abnormal performance for a Periwinkle. The trick is explained when we see the claws of the **Hermit Crab** (*Pagurus*) emerging from the mouth of the shell (Plate IX., fig. 3 B). A little amusement may be had from demonstrating the pugnacity of the Hermit. Being the unfortunate possessor of a delicate and unprotected body, he has to find a shell to put it in; and, further, he has to find more and more commodious premises as he gets on in life.

Another Gastropod, the **Grey Top Shell** (*Trochus cinerarius*), is very abundant. The conical, pointed shell is silvery grey, and marked by wavy lines of darker shades. When the external layer is removed the shell presents a beautiful pearly appearance.

A group of Mollusca, the **Nudibranchs**, characterised by having their breathing-apparatus or gills placed externally, and by possessing no shell, are represented by many species amongst the rocks. They bear a resemblance to slugs. When removed from their native element they are not attractive, but when under water, with their organs expanded, they are in many cases very lovely. In one family, exemplified by the **Sea-lemon** (*Doris pilosa*), the branchial plumes are protruded at will from a dorsal aperture, and spread out radially like a flower. In another family, of which *Eolis papillosa* is a representative, the branchiæ are in the form of papillæ, and placed along each side of the dorsal surface.

On ledges and stones between tide-marks we are sure to find rose-red, depressed structures with some resemblance to small sea-anemones in the sulks. If we touch one of them a fine jet of water will be squirted from a projection at its apex. These organisms are examples of the so-called **Sea-squirts** or **Ascidians.** Simple and structureless as they appear, the Sea-squirts have been discovered to be very highly organised. They were by the older authorities classed with the Mollusca, but they are now considered to be amongst the highest of the invertebrate series. They possess the rudiments of vertebrate structure. Besides the simple red form, *Cynthia grossularia*, we find readily enough examples of the compound forms, one of which is *Botryllus polycyclus.*

The latter is one of common occurrence on the surface of stones, and on the fronds of the Tangle, etc. It consists of a thin, jelly-like, hyaline, transparent layer, an inch or more across. Embedded in the gelatinous mass there occur numerous star-shaped purple bodies, with a minute distal aperture in each ray, and a central aperture in each rosette. Each ray of the rosette is an individual of the Compound Ascidian.

Amongst the spoil thrown on the beach one may find many forms both of animal and plant life never met with alive in the shore region. Occasionally a Porpoise is found cast ashore (Plate IX., fig. 11), in all likelihood having been captured in a fishing-net and drowned. It is highly interesting to watch the porpoises gambolling in summer, rising at short intervals to the surface and displaying a considerable portion of their glossy back and their dorsal fin. It takes an effort to convince ourselves that this creature, so finely modelled for an aquatic life, is not a fish, but an air-breathing mammal.

The cliffs between the Castle and the Harbour present features of considerable interest. It is not many years since the top was protected by a railing, put up at the suggestion of the late Mr. John Milne. The "Earthy Brae" owes its origin to its having been a free "toom" for a long time. It is at present largely clad with Hemlock.

Lady Buchan's Cave is situated in the face of the cliff nearly opposite the East End Infant School. It is seen in Plate VIII., fig. 8, as a dark spot on the cliff in the middle distance. It had been reached in former days by a pathway leading down the steep grassy slope a little to the east of the Cave, thence along a sandstone ledge lying a few feet above high-water mark, and by a stair, 3 feet 6 inches wide, cut in the sandstone. For many years the upper part of the stair has been reduced

verse, should have been permitted to become a ruin. The roofless Cave itself is now well protected by the existing concrete wall, but there is great danger of the means of access to it being completely destroyed, a large cavern having been cut by the sea underneath the remaining part of the stair. This cavern should be built up without delay. Steps should be taken at the same time to save the romantic relic from the damage being done to it by stupid vandals.

The fine piece of masonry farther east, called **Dennis Work,** effectually prevents the inroads of the sea at the Cathedral. Lyon relates that in 1330 James de Bane, Bishop of St. Andrews, issued a mandate forbidding anyone to break stones from the rocks on the north side of the Cathedral, or to remove those broken off either by the waves or by the "hand of violence," because of the danger apprehended by the encroachments of the sea. In 1372 a bull was granted by Pope Gregory XI. confirming a grant by Bishop Landel to the Prior and Canons of St. Andrews of the tithes of the parish church of Inchture and the chapel of Kinnaird towards the protection of the Cathedral from the same danger. It is said that in 1507 a prior entrusted with funds given by all the religious houses in the kingdom for the purpose of building a breakwater, decamped with a large part of the money, and the project had to be abandoned. The present concave wall, erected in Provost Playfair's time, was preceded by a straight wall, which a storm demolished when it was barely completed.

Tradition still existing in the city seems to show that at one time cows were grazed on the shore between the harbour and the Castle, and it is argued that there must have been a considerable extent of salt-grass or other grassy vegetation *en route.* No trace of such vegetation exists now. Old maps of the city do not show any margin of land in front of the cliffs. Patches might, of course, have existed, but be held to be too insignificant to be recorded by the cartographers. As an alternative suggestion, it is possible that cattle may have been taken there to browse on the seaweed. Similar remarks apply to the traditions regarding the existence of grazing-ground between the Castle and the sea.

On the cliffs above Dennis Work one may find examples of the **Creeping Cinquefoil** (*Potentilla reptans*), to all appearance truly native. But for the flower being yellow instead of white, this Cinquefoil might easily be mistaken for the Wild Strawberry.

Our excursion ends at the **Long Pier.** This does not look like a place where one would expect to find anything of botanical interest. Its phanerogamic flora may be said to consist of one plant,—the **Buck's-horn Plantain** (*Plantago Coronopus*). Plants of this interesting species flourish exceedingly well on the footway at the base of the parapet (Plate IX., fig. 10). Its hairiness is a noteworthy feature when considered in connection with the environment of the plant, being indicative of its xerophytic habits. This Plantain grows on the Castle ruins, the cliffs, and, as already remarked, the putting-greens at the Links. It has also made itself at home in the chinks of the causeway in South Castle Street.

Chapter X.

The East Sands.

THE East Sands extend from the mouth of the Kinness Burn to the Kinkell Braes, a distance of half-a-mile. At the place where the Burn enters the sea, the skerries—which rise in parallel series, and form the rocky shore between the West and East Sands—are lost to sight, with the exception of a few to the south of the "Burn Mouth," forming what is called the "Burn Stools." In comparatively recent years the projecting ledges there have been reduced in height by the pick. The fairway through which the Burn passes is narrow, and in stormy weather there is considerable danger of vessels drifting on the Burn Stools when entering the harbour. The entrance to the channel is marked by an unlighted beacon. Advantage would doubtless be taken long ago to use the estuary of the Burn as a haven.

After running in its strath for several miles in a general eastward direction, the Burn bends suddenly to the north, and then pursues a course parallel with the shore for a distance of 350 yards, its direction being thus altered by a sandy ridge called the **East Bents** (see Plate I., fig. 2). Near the mouth it turns abruptly and resumes its eastwardly course. The channel of the Burn behind the Bents constitutes the tidal harbour of St. Andrews. It is difficult to say what the original formation of the creek

PLATE X.

FIG.

1. The East Sands with Sea Lyme-grass (27th Aug. 1897).
2. Mature head of Goat's-beard (*Tragopogon pratensis*).
3. Beach at the old Marine Laboratory, with boulder clay.
4. Sea Rocket (*Cakile maritima*).
5. Purple Milk-vetch (*Astragalus hypoglottis*).
6. Beach at St. Nicholas, with agglomerate in the foreground.
7. Greater Knapweed (*Centaurea Scabiosa*).
8. Bulbous Buttercup (*Ranunculus bulbosus*).
9. Examples of agglomerate.
10. The East Sands after the storm of 25th March 1909.
11. Sand Couch-grass (*Agropyron (Triticum) junceum*).

PLATE X.

Bents are overlaid at the northern end with clayey soil, taken as mud from the harbour when it was deepened at various times. If the concrete wall at the Bents, built in 1877, had not been erected, it is highly probable that the sea would ere this have broken through into the harbour. Some of the posts of the old wooden breakwater may still be seen projecting from the sand, 9 feet out from the wall at its southern end.

The vegetation of the spit or peninsula forming the eastern boundary of the harbour has been altered very considerably from its pristine condition by the operations connected with the fishing industries, and it has not for long been such as to aid materially against the inroads of the sea. On the south side of the road leading to the Sands, where the Bents are flanked by the land, the vegetation has retained more of its native character; but, in spite of this, the inroads made by the waves in the absence of a protecting-wall have been very serious, especially of late. Here, as at the West Sands, the plant chiefly instrumental in binding the loose sand is Marram Grass or "Bent." In days gone-by a perpendicular wall of sand, left after attack by the sea, was quite a familiar sight. For a considerable number of years previous to 1898 a period of reclamation ensued, and sheer faces were no longer seen. The **Sea Lyme-grass,** for long established at the southern end of the Sands, spread northwards, and occupied the shore from the cliffs to within a hundred yards of the road at Woodburn, and in time a bench, raised a few feet above the level of the sandy shore, and extending forwards from the brae a good many yards, was formed (Plate X., fig. 1). The banks became clothed with fine vegetation, constituting a comparatively rich flora. It looked as if the Lyme-grass were likely to conquer, as it had done at the West Sands, but a combination of a very severe storm and an exceptionally high tide undid in a few hours what had taken years to accomplish. My notes show that this storm took place on the 18th Oct. 1898, and lasted over the 19th.

At the West Sands the waves exhaust their energies in rushing forward over the low mounds and plateaux, and recoil is obliterated; but at the East Sands there is always danger of recoil, the fairly level beach ending abruptly in a face of some height. The Lyme-grass under these conditions proved insufficient to battle with the waves, and it was swept away, with the exception of a small patch of it which was sheltered by the rocks at the south end, whence it had spread. Since that catastrophe, the sea has again and again advanced with disastrous effects on the Bents, and great quantities of sand have been excavated from the banks and strewn on the shore.

Some urge that the damage is largely due to the removal of quantities of sand and gravel from the shore. Strong arguments can be adduced to combat that opinion. The event just described happened suddenly. It was by no means due to the immediate removal of sand or gravel. The erosion at that time threw back on the foreshore a far greater quantity of sand than had been removed by carts for many years, or would likely be removed for years to come. There is no sign of retardation or stoppage of the erosion. Almost every year, further inroads are made, the latest one being due to the storm of 25th March 1909, which seriously threatened the foundations of the Marine Laboratory (Plate X., fig. 10).

Some other cause than the removal of sand, etc., for building and other purposes, must be sought in explanation of the recent inroads. It might appear that, previous to the storm of 18th Oct. 1898, it had been simply a matter of good fortune that the process of reclamation had not been checked for many years, and further, that the storm of that date must have been the outcome of an unusual concentration of destructive forces. The lengthening of the Long Pier, a work begun in May 1898, must be taken into account. The effect of this, and the fact that severe erosion has continued during the years subsequent to the date of lengthening and the building of the groin at the cross-pier, have led competent observers to believe that those erections have had much to do with the seriousness of the inroads the sea is making now at the East Sands. They are demonstrably responsible for changes in the distribution of the sand towards the harbour. In September 1909 a large bank of sand filled the channel at the outer end of the Long Pier, causing the Burn to change its course at a point close to the foot of the old sloping stair, 130 yards from the pier-head, and to pass in a south-east direction, and debouch amongst the rocks of the Burn Stools, 70 yards from the pier. One branch of the stream found its way into the sea at the East Sands, 100 yards farther south.

The Town Council has taken cognisance oftener than once of the advancement of the sea at the East Sands. It passed a resolution on 19th July 1830, prohibiting the removal there of gravel, sand, and stones. In a Minute dated 18th March 1845 we read: "The Provost brought under the notice of the Meeting the extensive encroachments which the sea had lately made at the Bents which form the barrier betwixt it and the harbour. . . . It was stated that the sea has encroached on the Bents during the last 25 years to the extent of at least 150 feet, some of those present recollecting two cargoes of Baltic timber lying on the green turf over a space now entirely covered by the sea at high water; the barrier has now worn so thin that it is feared a heavy gale happening at the same time with high tides would make a complete breach. . . . It was mentioned that in comparison with so mighty an agent

In this connection, the visitor to the city has little idea of the appearance many of our streets presented only a few years ago. Abbey Street, for instance, was laid with rounded water-worn stones, and the noise that the old stage coaches, proceeding to Anstruther and Crail, made in their passage over the causeway, showed how hard the boulders were, and how unevenly they lay in their bed.

When the boulder clay close to the East Rocks is clean-swept, another geological feature of great interest presents itself there, namely, the exposure of volcanic rock *in situ*. No other igneous rock lies nearer to the city. It forms part of a **Volcanic Neck**, represented by patches and bands of **agglomerate** here and there on the shore amongst the sedimentary rocks, and a mass on the brae face opposite St. Nicholas farmhouse. I am glad to be able to submit an original survey (Plate X.A), showing the position of the exposures to scale. The volcanic rock is indicated by thickened lines and dotted masses. The region in which the exposures have been noted is 700 yards in length. A part of the agglomerate may almost always be seen where the small stream—bridged at the commencement of the uphill path to the Braes—runs over the Sands at high-water mark (Plate X., fig. 6). Here, as elsewhere, the agglomerate varies much in composition, some examples being very coarse, with conspicuous pieces of sandstone, coal, etc., embedded in the magma; while, at the opposite extreme, others may be found composed of the finest ash (Plate X., fig. 9). An exposure runs almost in a line from the boulder clay, in an easterly direction, reaching, and in a measure surrounding, a large detached mass of sandstone 90 yards from the shore. Two very small portions of tuff lie amongst the rock-pools, between the mass mentioned and the base of the cliffs. In the whin-covered knoll opposite the farmhouse the agglomerate appears as the "rotten rock" of the agriculturist, and its presence there

VOLCANIC ROCKS AT EAST SANDS.

patches which, when in full blow in the beginning of June, can be seen from afar. It is quite easily distinguished from our other buttercups by the well-known feature—its completely reflexed calyx. This character is no doubt associated in some way with the dry conditions in which the species finds itself. The petals are a bright golden yellow. The leaves are distinctly hairy. The " root " forms a very interesting object of study. It is in common language called bulbous, whence the name of the species. The bulb-like swelling is known botanically as a corm. It is a condensed stem or rhizome, not unlike the corresponding part of the Crocus. Being filled with starch granules, it is obviously a store of reserve material against a period of scarcity. Its development may be studied by lifting specimens at various periods.

At one part of the Bents, the **Greater Knapweed** (*Centaurea Scabiosa*) (Plate X., fig. 7) may still be studied. Its xerophytic character is well displayed in its extremely strong roots, which penetrate the sandy soil to a great depth. The leaves are of rather attractive shape. In the young condition they are thickly covered with hairs. The flower-heads are purplish-crimson. The involucres—the imbricated scaly coverings of the flower-heads—are not nearly so dark-coloured as those of the Black Knapweed (*Centaurea nigra*), a very much commoner species which may be found at every roadside. As in the other Centauries, the outer ring of florets is larger than the rest, and the increase in size is got at the expense of the suppression of the reproductive organs.

The perfect central florets of this and other Centauries are of unusual interest, owing to sensitiveness displayed by them. The phenomenon is particularly well seen in the **Corn Flower** (*Centaurea Cyanus*), sometimes found in the neighbourhood. The anthers are united together to form a hollow cylinder, enclosing the undeveloped style, which lies like a piston in the tube. When an insect alights on a flower in this stage, its presence is enough to excite movement in the anthers, which is visibly shown by the pollen welling out in a considerable stream at the top of the tube. This phenomenon is due to the shortening of the filaments which, like guy-ropes, stretch between the bases of the anthers and the tube of the corolla. The contraction occurs in response to the stimulus conveyed to the filaments through the shaking of the anthers by the insect. The action may be imitated by touching the anthers with a pencil point, when, if the floret has not been stimulated shortly before, a quantity of pollen will issue. If the floret is still young, a further welling forth of pollen will occur on stimulation, provided that a short interval of rest has elapsed. Before long, the style lengthens and pushes the stigma beyond the tube, the remainder of the pollen being swept out by it. An insect, dusted with the pollen which wells from a younger floret, deposits some of it on the protruding stigma of a neighbouring and older floret, thus accomplishing the object for which the whole complicated mechanism is intended, namely, the fertilisation of one floret with the pollen of another.

A characteristic sand-dune grass, the **Sand Couch-grass** (*Agropyron (Triticum) junceum*) (Plate X., fig. 11), occurs in fair abundance. It supplements in a fairly effective way the work of the Marram and the Sea Lyme-grass. It resembles the former in having very narrow leaves, and for like reason. The ear is a loose one, composed of comparatively few spikelets. This grass is considered by some to be a seaside variety of the Common Couch-grass (*Agropyron repens*), but so distinct is it with us, that unless one were aware of the existence of gradational forms, it would unhesitatingly be raised to specific rank. If regarded as a variety of the Couch-grass, it is interesting to see how, in adapting itself to the arid conditions of such places as the Bents, it has assumed the xerophytic characters.

The **Goat's-beard** (*Tragopogon pratensis*) occurs on the Bents, being most numerous within the enclosure of the Marine Laboratory. It belongs to the milky group of Composites, having as allies the dandelion and lettuce. It may be easily recognised amongst the surrounding vegetation by its grass-like leaves and its characteristic flower-heads. Its roots are not unlike those of the dandelion. The height of the flower-stem is about 18 inches. The flower-heads open early in the morning, and close with great regularity at mid-day. When closed, the long bracts or segments of the involucre are approximated at their apices, tapering finials being thus formed which cannot be mistaken. Another striking feature has yet to be noticed. By-and-by the heads expand after the manner of the dandelion (Plate X., fig. 2). They are, however, much larger and of stronger texture than the dandelion's. Prof. Bell Pettigrew, in his 'Design in Nature' (p. 418), describes the "seed" as follows: "The goat's-beard forms a typical parachute which for elegance of design and efficiency cannot be surpassed. It consists of an exquisite flattened disc slightly depressed in the centre; the free margin being a little turned up. It is supported in every direction by tapering structures, which radiate from a central point at regular intervals. Between the radiating structures a most delicate network of vegetable fibres resembling the finest filigree work extends, imparting to the whole a delicate gauzy appearance which indicates extreme lightness and suggests the idea of flotation or flight. The radiating supporting structures display very graceful double curves; those nearest the centre of the disc having their convexities directed upwards, those at the periphery or free margins having their convexities turned downwards. Depending from the centre of the disc is a

The **Dove's-foot Crane's-bill** (*Geranium molle*) abounds in the same place, and may with interest be compared with the above members of the Geranium family. It is characterised by being annual or biennial, and having its leaves covered thickly with soft hairs.

In the same field the **Scarlet Pimpernel** or **Poor Man's Weather-glass** (*Anagallis arvensis*) is usually to be found. It bears very little resemblance to the Bog Pimpernel (*A. tenella*) already described. The latter is a perennial growing in a moorland marsh, while the former is an annual growing in a dry, sandy soil. It is very well known that the flowers of the Scarlet Pimpernel are highly sensitive to changes in the atmosphere, and close up when rain is imminent. In good weather they close with considerable regularity in the early afternoon.

A little above high-water line there used to be found, up till the past year, 1909, a number of plants which were conspicuous when in flower, on account of their resemblance to the garden Stock—viz., the **Sea Rocket** (*Cakile maritima*) (Plate X., fig. 4). This species is an annual, with glabrous, fleshy, pinnatifid leaves, the flowers purplish, and the fruits consisting of two indehiscent joints, each containing a single seed. The Sea Rocket occurs on the West Sands, and it is to be hoped that its disappearance at the East Sands is only temporary.

Another strand plant, and one which has held its ground in spite of the erosion and the shifting of the sand, is a seaside **Orache**—*Atriplex rosea* (*A. Babingtoni ?*). It is still to be seen in large numbers in summer and autumn at the south end of the Sands, above high-water mark. Being an annual, it is perpetuated by seeds, which lie in the sand during the winter. Its lower leaves are hastate, the upper ones more strap-shaped. The whole plant is fleshy, and is usually tinged with purplish-red. The fruit is single-seeded, and when the seeds are ripe they are enclosed in much-enlarged bracts which bear tooth-like external protuberances. Varieties occur which are devoid of any purple or red colour. It is interesting to note that the Orache is related to the Glasswort or Marsh Samphire and the Prickly Saltwort—described in chap. v.—and also to the garden Spinach.

While the East Sands offer to both the botanist and the geologist much to attract them, they are also a veritable Mecca to the zoologist, because they have for the past five-and-twenty years been the site of a notable **Marine Laboratory.** Shortly after Professor M'Intosh became occupant of the Chair of Natural History in the University, he made a successful effort to establish a Laboratory for marine research. A plain wooden building (Plate X., fig. 3), which had been hurriedly erected by the Town Council as a Fever Hospital, but soon disused for this purpose, was secured, and, with the aid of the Fishery Board for Scotland, fitted up with appliances for the study of Marine Biology. The largest room was furnished with a series of wooden tanks, placed in a stepped manner so that the water could pass from the higher to the lower. The water was pumped in the first place into a large concrete cistern sunk in the sandy soil behind the Laboratory. From this cistern it was then pumped to an elevated one, whence it flowed in a steady stream through the tanks in the tank-room. The rest of the main building consisted of two apartments, the smaller being the Professor's private laboratory, and the larger the general laboratory, where five or six workers could carry out research. Much work of the very best quality was carried out in the old building, in spite of high temperatures in summer and low ones in winter. The research into the development of the food-fishes occupied a very prominent place in the programme, and many of them were there seen in their earliest stages for the first time. In order to interest visitors some tanks were tenanted by denizens of St. Andrews Bay and its shores.

The whole Laboratory was enclosed by a paling, and the strips of sandy soil planted with shrubs and flowering-plants. One plant flourished particularly well there, namely, the **Edelweiss** (*Leontopodium alpinum*). As is well known, this plant is a native of the Alps, and is much sought after by tourists,—so much so, indeed, that it has been found necessary to take measures to prevent its extirpation. Lives have frequently been lost in the endeavour to procure specimens of this plant. In its native habitat the snow covers it deeply, and is the means of protecting it from the rigours of winter. But for the snow the plant would certainly succumb. The Edelweiss plants at the Marine Laboratory were within a few yards of the sea, and if snow fell, it lay there for only a short time. Frosts are much less severe close to the sea than inland. The same plant flourished very well in the University Botanic Garden. In both places large clumps were formed, bearing in the summer many of the prized flower-heads.

After serving its purpose usefully for twelve years, the "shanty down by the shore,"—as the student poet, the late Robert F. Murray, in good-humoured banter, called the Laboratory,—had to give place to a building more worthy of the University. The late Dr. Charles Henry Gatty became so much interested in the work of marine research that was being carried on here by Prof. M'Intosh and his students, that he offered the University the sum of £2500 for the purpose of building a more substantial Laboratory. Ground was chosen for the structure on the Bents adjacent to St. Nicholas farm, and close to the sea. This fine addition to the equipment of the University (Plate X., fig. 1) was opened on 30th Oct. 1896, under the name of the Gatty Marine Laboratory.

PLATE XI.

FIG.

1. Maiden Rock from the south-east.
2. Shoot of (A) Watercress (*Nasturtium officinale*); (B) Brook-lime (*Veronica Beccabunga*).
3. Bulb of the Wild Hyacinth (*Scilla non-scripta*).
4. Kinkell Cave from the east.
5. A Lichen, *Ramalina scopulorum*.
6. Wild Hyacinths in flower.
7. Early Purple Orchis (*Orchis mascula*).
8. Barren Brome-grass (*Bromus sterilis*).
9. Rock and Spindle from the south-east.
10. Wood Anemone (*Anemone nemorosa*).
11. Common Horse-tail (*Equisetum arvense*).

PLATE XI.

allow of terraces being carved out. Those in question are so well marked round a great part of our coasts as to leave no doubt with regard to the mode of their origin, and it is usual to designate them as the 25-feet, the 50-feet, and the 100-feet terraces.

The deep cart-road we pass up used to lead from the Brownhills fields to the Sands, but several years ago it was closed at the top, when the wall there had to be placed back to permit of a new footpath after the old one had been carried away by a fall of rock. On the gravelly bank at the top of the road we find the **Rock Rose** (*Helianthemum vulgare*), a procumbent shrubby plant with bright yellow flowers. When a flower is touched with a pointed instrument anywhere at the base of the petals, all the stamens are seen to spread out simultaneously from the centre, with a swinging and fairly quick movement. This sensitive response has reference to the cross-fertilisation of the flowers by insects. The Rock Rose is a member of the order Cistaceæ, not Rosaceæ.

Beside the Rock Rose we find, along with other flowering-plants, the **Kidney Vetch** or **Lady's Fingers** (*Anthyllis Vulneraria*). This plant possesses a stout, perennial root-stock; the leaves pinnate, clothed with silky hairs; the flowers in crowded heads, which are generally in pairs; the calyx inflated, hairy, and eventually enclosing the small pod; the corolla small, yellow or red.

Two true Roses are soon met with, viz., the **Dog Rose** (*Rosa canina*) and the **Downy-leaved Rose** (*R. tomentosa* or *R. mollissima*). Every botanist knows that the Roses are a very variable group. In the 'London Catalogue of British Plants' (10th ed., 1908) twenty-two sub-species or varieties of the Dog Rose are named; and in Hayward's 'Botanist's Pocket Book' (13th ed., 1909) the Downy-leaved Rose is credited with fifteen. The two Roses are almost alike in general appearance, both forming strong bushes. The leaves of the Dog Rose are glossy and scentless; those of the Downy-leaved Rose dull, with a coating of down, and somewhat fragrant. The flowers of the former are pink or white, and the fruit ovoid and destitute of bristles; the flowers of the latter rose or white, the fruit globose and covered thinly with bristles.

The panorama of the rocks below is a memorable one, the strata betokening in their twisting and tilting the operation of tremendous forces. From the Step Rock to the Pier we found the outcrops of the strata parallel all the way, but at Kinkell that uniformity gives place to violent disturbance.

If we descend to the shore, at a point a little beyond a wicket, we shall soon reach a sandy cove where, at its eastern edge, traces of the chisel are seen in a mass of sandstone. The ochry water issuing from the base of the rock was prized a generation ago as a tonic. This "**Chalybeate Spring**" was made accessible by Provost Playfair, but for many years it has been neglected and forgotten.

In the clayey, damp hollows near by we shall easily find the **Common** or **Corn Horse-tail** (*Equisetum arvense*). It is regarded as a weed by the agriculturist, and so it is. It is singular to find how few of one's acquaintance have ever observed the spore-bearing shoots (Plate XI., fig. 11, on right) of this plant. These reproductive shoots arise before the green, branching, vegetative ones (fig. 11, on left), and are objects of very much interest. They are pinkish and brittle, and bear at their apex a neat cone. When mature, about the beginning of May, if the stalk is struck, a cloud of very fine powder is shaken from the cone. This dust, under the microscope, presents an extraordinary appearance, the spores being in a state of visible activity. The movement is due to the coiling and uncoiling of two long, narrow bands which are attached to the spores. Being hygroscopic, the breath of the observer causes them to uncoil.

A short distance beyond the Spring we reach a marsh elévated a few feet above the shore. Here we find the **Smooth Water Horse-tail** (*Equisetum limosum*). It is a much taller, stronger plant than the Corn Horse-tail. Its stems are round and smooth, sometimes with branches, sometimes without them. The spore-bearing cones are borne on stems which do not differ in appearance from the purely vegetative ones produced at the same time.

Other denizens of the marsh may be noted. The **Small-flowered Willow-herb** (*Epilobium parviflorum*) is a member of a genus represented in gardens by a weed, the Broad Smooth-leaved Willow-herb (*E. montanum*), whose leaves are not unlike those of the Fuchsia,—a plant belonging to the same Natural Order. The Small-flowered Willow-herb is clothed with soft hairs. The corolla is purplish-rose, and only $\frac{3}{8}$-inch in diameter. When young, the seed-vessels of the Willow-herbs are very long and narrow. The fruit at maturity splits, from the top downwards, into four parts, exposing the seeds, each of which is crowned with a tuft of fine hairs. A rarer species is to be found elsewhere on the Braes,—the **Square-stalked Willow-herb** (*E. tetragonum*). Like the above, it is perennial and a lover of marshy places. Its stem is erect, 2 feet high, and rendered somewhat quadrangular by four slightly developed ridges which descend in twos from the leaf-bases. The leaves are almost sessile, shining, strap-shaped or lanceolate, and finely toothed.

In the same marsh the **Square-stemmed St. John's-wort** (*Hypericum tetrapterum*) is met with. This plant is distinguished by having quadrangular, winged stems. The flowers are pale yellow, $\frac{1}{2}$-inch across, and borne in a somewhat dense inflorescence. The very numerous stamens

The **Encrinite Bed** (see chap. viii.) crops out a few yards to the east of the Maiden Rock, and passes into the grassy bank. It is clearly exposed on the rocky shore beyond the edge of the sand. About 190 yards eastward, the crest of a grand example of an anticline is crossed, and it is an interesting exercise to complete in imagination the great arches whose bases only are left jutting out as serrate ridges on the foreshore. A fine "**saddleback**" forms the cliff-face here. The Encrinite Bed appears again 50 yards farther on, beneath a little cave, and close behind a high and jagged ridge of red rock dipping to the east. About another 80 yards eastward, in a creek between bold ridges, and floored with denuded blue shales, the **Myalina-limestone** comes to the surface at a high angle, and may be traced easily where it runs up into the earthy bank.

Certain of the dells here are marshy. In them we find the **Yellow Flag** or **Water Iris** (*Iris Pseudacorus*), interesting in respect of its equitant leaves and the unusual structure of its flowers. The stigmatic surfaces are found as triangular flaps at the outer ends of the three petaloid rays of the style which overarch the anthers.

The **Marsh Marigold** (*Caltha palustris*) is also present. The leaves are reniform and glossy, with large membranous stipules. The flowers are notable on account of the sepals constituting their conspicuous part, the petals being absent.

Along with the above it is not unusual to find a mass of green vegetation like Chickweed. It is the **Water Starwort** (*Callitriche verna*). The flowers are greatly reduced in structure, and appear in the axils of the leaves. Very often a staminate or male flower occupies the axil of the leaf on one side of the stem, and a pistillate or female flower the axil of the opposite leaf.

The **Cuckoo-flower** or **Ladies' Smock** (*Cardamine* *pratensis*) has a preference for a somewhat marshy spot. It is a lilac- or white-flowered, showy Crucifer, with pinnate leaves. Vegetative propagation occurs by the production of buds on the radical leaves.

Large tracts of the Braes are covered with the **Great Wood-rush** (*Luzula sylvatica*). This plant possesses a creeping root-stock, and forms strong tufts. It succeeds uncommonly well in the struggle for territory. The leaves are grass-like, broadly-linear, channelled, firm in texture, and fringed with long hairs. The flowers are small and brown, and grouped in clusters disposed in loose panicles which rise to the height of 18 inches. The **Field Wood-rush** (*L. campestris*) is very common in dry grassy places and in the pastures above the Braes, appearing singly or in patches. It is a small plant with a slender flower-stem, 3 to 10 inches high.

On dry brae-faces we meet with groups of a plant extremely like the Common Groundsel in general appearance, but much taller, being 2 feet high,—the **Mountain** or **Heath Groundsel** (*Senecio sylvaticus*). The leaves are somewhat viscid, the ray florets very small and rolled back, and the fruits covered with minute, appressed, silky hairs. This species should be compared with the **Ragwort** (*S. Jacobæa*), to be found in abundance in the pastures near at hand.

A plant which attracts very little attention, by reason of its somewhat commonplace appearance, is the **Earth-nut** or **Pig-nut** (*Conopodium majus* or *Bunium flexuosum*). It is a plant with a single, erect stem, a foot or more in height; the leaves parsley-like, finely divided; the flowers very small, white, and borne in compound umbels. The rootstock consists of a solitary, rounded tuber, ½-inch in diameter, resembling a nut. The tubers are edible, and are usually called "arnuts." One seldom sees them dug for nowadays. They would form a part of the food of the wild boar when this countryside constituted the "Cursus Apri."

In the early part of summer the Braes are starred thickly with the **Wood Anemone** (*Anemone nemorosa*). This plant is usually seen at its best in open woods composed of hardwood trees, the blossoms being past before the trees produce their canopy of leaves; but it could scarcely be finer than here in the moist hollows facing the north and the sea (Plate XI., fig. 10). In many cases the flowers are deep rose-purple. The Anemone, like its relative the Marsh Marigold, is interesting botanically in the coloured part of the flower being the calyx. Three cut involucral leaves, resembling those which rise from the root-stock, radiate from a point on the flower-stem at a considerable interval from the flower. In the Hepatica, a foreign Anemone, the involucral leaves are of such a shape and so placed as to bear a remarkable resemblance to a calyx.

The **Primrose** (*Primula vulgaris*) bedecks the Braes in abundance, but the Cowslip (*P. veris*) is not met with within easy reach of the city. The dimorphism of the flowers of the Primrose is a feature which never loses its interest to the naturalist. One plant bears long-styled flowers and a neighbouring plant short-styled ones. Fertilisation of the flowers is understood to be largely due to the visits of moths at night, and to a less degree to bees during the day. Darwin's experiments showed that self-fertilisation resulted in a reduced yield of seed, the full complement being only got when the union was between the "pin-eyed" and the "thrum-eyed" flowers.

A pretty pea-flowered plant helps to adorn the dells, —the **Tuberous Bitter Vetch** (*Lathyrus macrorrhizus*). The leaves have no tendrils, and the flowers are reddish-purple, changing to blue in fading. The rootstock is creeping, and bears tuberous swellings at intervals. This is one of our plants which, when dried, turn black.

of that very peculiar little plant, the **Tuberous Moschatel** (*Adoxa Moschatellina*). This plant chooses a shady, damp spot in which to pass its "inglorious" existence. It is a small herb, with 1 to 3 light-green, glabrous, flaccid, biternate or triternate leaves, the segments being deeply lobed. The flower-stem, 3 to 6 inches high, bears above the middle a pair of small, short-stalked, ternate leaves, and is terminated by a globose flower-head, about $\frac{1}{2}$ an inch in diameter, and composed of 5 yellowish-green flowers. The musky odour of the flowers is attractive to insects. The fruit is a pale-green berry, one-fifth inch in diameter. The rootstock consists of a creeping rhizome, bearing a few thickened scales. The family relationship of this strange plant—the only representative of the genus—has been disputed, but most systematists are agreed in placing it in the Honeysuckle family. The **Common Honeysuckle** or **Woodbine** (*Lonicera Periclymenum*) is to be met with on the Braes, and a number of plants also occupy the Maiden Rock. Points of resemblance between the Moschatel and the Honeysuckle are hard to find.

The dripping wall of the Cave is covered with the **Common Golden Saxifrage** (*Chrysosplenium oppositifolium*), as far in as the minimum light requirements of the plant will permit. Its habitat is thus entirely different from that of the Meadow Saxifrage above noted. One peculiarity connected with the preference of the former for a shady place is the entire loss of its petals. The calyx remains, but is greatly reduced, being only $\frac{1}{6}$-inch across. The flowers, such as they are, are golden yellow. They are borne in flat groups, and backed by leaves. The leaves of the stem are opposite and stalked, the blade roundish, crenate, succulent, and bearing a number of stiff, transparent hairs on the upper surface.

A great part of the dripping wall is covered with vegetation of a lowly type, consisting of **frondose Liverworts.** Reference has already been made to the foliaceous Liverworts and their relationship with the Mosses (p. 74). The name Liverwort is appropriate to such fleshy plants as inhabit the Cave. Two species are represented. In one, *Fegatella conica*, the frond is forked, firm, bright green, glossy, and beautifully netted, a glistening dot existing in the centre of each mesh. The dot marks the mouth of an air-chamber. When bruised, the frond emits an aromatic fragrance. The other species, *Pellia epiphylla*, is destitute of the meshwork, more tender, and somewhat pellucid. When the reproductive organs occur, they are well worthy of attentive study.

In the dell near the mouth of the Cave there is a large bed of **Ramsons** or **Broad-leaved Garlic** (*Allium ursinum*). It is not without a beauty of its own when its pure white blossoms cover the hollow. This Allium offers a great contrast to its relative, the Crow Garlic (*A. vineale*), already described, in respect of its adaptive structural characters. Its leaves are stalked, wide, flat, and comparatively thin. The bulb is narrow, elongated, and unprotected, save for a few fibres. The flowers are borne in flat-topped umbels, and there are no bulbils associated with them. The plant rejoices in the shade and the rich moist soil.

In dry ground, above this hollow and elsewhere, the **Wood Sage** (*Teucrium Scorodonia*) will be seen in plenty. The stems are a foot high, quadrangular and tough; the leaves triangular-ovate, serrate, the upper side rugose, the underside downy and pale; the veins prominent. The flowers are in pairs, pale yellow, arranged in one-sided, spike-like racemes.

Another lover of dry banks is the **Golden Rod** (*Solidago Virgaurea*). When in flower it cannot be mistaken for any other Composite on the Braes. Its stem is a foot or more in height. The inflorescence is a narrow, crowded panicle of numerous golden-yellow capitula of the Aster type.

The **Corn Salad** or **Lamb's Lettuce** (*Valerianella olitoria*), a member of the Valerian family, is fairly common. It is seldom more than 6 inches high. The stems are generally forked, the leaves strap-shaped or oblong, the flowers very small, pale blue, in dense cymes ½ an inch in diameter.

As previously mentioned, the Sea Lyme-grass has entirely disappeared from the sandy bay beneath the Cave, but the **Sand Couch-grass** (*Agropyron junceum*) is flourishing there, and helping to form a small, grassy platform.

A short distance beyond the Cave there is a hollow in which the **Wild Hyacinth** or **Bluebell** (*Scilla non-scripta* or *S. nutans*) grows in particularly rich profusion. The illustration given (Plate XI., fig. 6) is from a photograph taken towards the end of May. At that time the Wild Hyacinths fill many of the valleys with beautiful purplish-blue sheets. The effect is perhaps most exquisite when seen from a little distance out at sea, the masses of bloom appearing like coloured haze floating in the hollows. The bulbs (Plate XI., fig. 3) lie somewhat deep in the ground. The flowers droop when fully expanded, but become erect when they develop into fruit. The perianth-segments are slightly united at the base, and the three outer filaments are attached to the outer segments for a great part of their length.

In this region and elsewhere the **Early Purple Orchis** (*Orchis mascula*) (Plate XI., fig. 7) is fairly common. The flowers of this Orchis are very attractive, and they are also highly interesting on account of their structure. The stigma forms a cavity, not a projecting body. This cavity is overhung by a knob. If we imitate the action of

very short stalks. The bright blue flowers are arranged in racemes in the axils of opposite leaves.

At Kinkell Ness—a promontory about $1\frac{1}{4}$ mile from the East Sands—we see a rough natural rockery between the path and the sea. Inspection of that region of rough boulders reveals one of our rarer seaside plants, the **Scottish Lovage** (*Ligusticum scoticum*). This plant reminds one very strongly of Celery, itself in the wild form a seaside plant. The Lovage finds a foothold for its thick rootstocks in the chinks of the sandstone a few yards from the sea. The stems are dull purple, the leaves deep green and shining, the flowers white or pink, in many-rayed umbels.

At the Ness the pathway turns to the right and follows the direction of the cliffs, which trend to the south and form a bay of considerable extent. In a minute or two we find ourselves in a place wearing a weird and enchanted look. The rocks are no longer such as we have trodden all the way out, but uncanny-looking material, which seems but yesterday to have been poured out in a molten state and to have assumed fantastic shapes. We almost instinctively look to find the place where the molten material has found its way up through the sandstones, shales, and coal. Parts of the margins of the funnel are found readily enough. Everywhere there is evidence of the fact that the volcanic magma has brought up pieces of the rocks through which it has passed, and carried them hither and thither. We must refrain from fancying for a moment that the dark masses standing on the shore were formed as we now see them. Like the Maiden Rock, they have been produced by the denudating action of the sea on a mass of solid rock, the harder portions being left standing in isolation. The most interesting of all the masses is the tallest one, and its special feature is not seen until we have walked on and viewed it from the far side

(Plate XI., fig. 9). Then we see what helps us to understand why this mass has been called the **Rock and Spindle.** In it we have a colossal representation of a spinning-wheel, the top part corresponding to the distaff or "rock," and the wheel-shaped projection forming the spindle. The Rock and Spindle differs from the Maiden Rock in being surrounded by the sea at high tides, and is therefore still subject to some erosion. The problem of its geological structure is a puzzling one. It may be briefly elucidated as follows. A portion of the stack is composed of material which is different from, and has been intruded into, the tuff which composes the main mass of the neck. Owing to its being full of fragments of various rocks caught in its passage upwards, this material presents the appearance of a coarse agglomerate. Another part of the stack consists of a rock quite distinct from the above, being a close-grained basalt. It is the latter which has formed the Spindle, and the wheel-like formation is explained on the theory that a cavity had existed, into which the basalt had been injected, and on cooling had taken the radiating, columnar form shown in the part exposed to view. The truncated, polygonal ends of the prisms appear beneath on the west side like a piece of compact masonry.

The phanerogamic flora of the Rock and Spindle is of the most meagre kind. When I botanised the somewhat inaccessible top of it some years ago, the only flowering-plant I found was the **Barren Brome-grass** (*Bromus sterilis*). The specimen gathered on that occasion is illustrated in Plate XI., fig. 8. This grass is seen to possess matted roots. It is 12 to 18 inches in height. If the specimen had been taken earlier in the season, the drooping position of the branches of the panicle, and the numerous long awns of the spikelets, would have been shown.

A cart-road with wheel tracks deeply rutted in the rock runs close beneath the Rock and Spindle into the creek which at one time was dignified by the name of **Kinkell Harbour.** The existence of the harbour was recalled when the right-of-way on Kinkell Braes was disputed. A well-known pilot and boat-owner was a witness for the defence, and he deponed that he had taken very valuable cargoes into that harbour. On being interrogated as to the nature of the very valuable cargoes, he replied with animation, "Ladies and gentlemen, old and young!"

PLATE XII.

FIG.

1. Myalina-limestone bed.
2. Portion of Shell-limestone.
3. Qua-qua-versal strata.
4. Buddo Rock from the south.
5. Buddo Rock from the west.
6. Kittock's Den—lower part.
7. Cliffs at the mouth of Kittock's Den.
8. The Whale Rock from the west.
9. The East of Fife Teachers' Field Club at Kinkell.

PLATE XII.

rests on carbonaceous shales, which, being comparatively soft, are excavated by the waves, hence the undermining seen in the illustration. The strata here are pierced by volcanic rock. The lofty mass behind the limestone, on the right, is composed of agglomerate, with an intrusion of basalt. Quantities of the limestone have been caught up by, and incorporated in, the volcanic magma. The prominent mass on the left is indurated sandstone.

Pursuing our way out, and passing a rugged corner, where a narrow wicket-gate is fixed to the rock, we immediately reach a small sandy bay. This spot should be visited when the tide is well back. If we ascend the sloping brae beneath the cliffs, and look down, we will see a magnificent example of what geologists term a **qua-qua-versal dome** (Plate XII., fig. 3). In our journey thither we have seen numerous examples of anticlines and synclines,—that is, arches and troughs,—but here we find a periclinal arrangement, the rock ledges sloping away to all points of the compass. Their outcrops are chiselled across by the waves, and form a fairly perfect series of concentric circles. The lay observer, when he views these circles, can scarcely help harbouring some notions that would not accord well with scientific data, it being hard to believe that the strata so disposed were at one time flat and level.

To the east of this dome, and contiguous to it, we find another, but less perfect, one. Passing over it, we come to a salt marsh bordering on the sea, and extending towards a large and picturesque mass of agglomerate (Plate XII., fig. 8). This mass is commonly called the Whale Rock, the name being connected with the stranding of a whale near it many years ago.

The ground that we have traversed offers the botanist a rich field. At various points the **Meadow Crane's-bill** (*Geranium pratense*) occurs sparingly. It is a perennial, often over 3 feet in height, with the largest leaves 3 or 4 inches across, and deeply cleft into 7 to 9 boldly cut segments. When they fade they assume a fine crimson tint. The flowers are 1 inch in diameter, and bluish-purple. A white-flowered variety has been known to persist in the neighbourhood of the Rock and Spindle for many years.

In the region beyond the range of inveterate flower-gatherers, the **Purple Foxglove** (*Digitalis purpurea*) is to be seen adorning the dells. It has been well described as the "most stately and the most beautiful of our herbaceous plants." No detailed description is needed. The flowers are admirably adapted for insect fertilisation. The humble bee is seen to fit the tube neatly when it clambers up in quest of the honey which is secreted at the base of the flower. In this connection Mr. G. F. Scott Elliot, in 'Nature Studies,' remarks: "It agrees in shape almost exactly with the body of the humble bee which visits it; and one can scarcely escape the conclusion that generations of Bumbles have in some way pressed the foxglove flower out into its present form." The anthers and stigma are placed together near the roof of the tube. The anthers are in two pairs, dehiscing downwards, and they shed their pollen before the stigma lobes open. A bee entering a young flower has its back dusted with pollen, and, passing into an older flower, in which the stigma lobes have divaricated, necessarily deposits some of the pollen on them. The bees commence with the lowest and oldest flowers, and work upwards. If not fertilised by bees, self-fertilisation is very likely to take place when the corolla falls off, carrying with it the stamens whose anthers dust the stigma in their descent. In a series of **hybrids** I raised between the foreign Yellow Foxglove (*D. lutea*) and the white variety of the Purple Foxglove, the flowers were much smaller than those of the latter parent, and the humble bees, finding it impossible to enter the tubes, pierced them from the outside to reach the honey.

Two species of Scabiosa are abundant. One is the **Field Scabious** (*Scabiosa arvensis*). It is a plant 1 to 3 feet high, branching considerably; the leaves hairy, the lower ones lanceolate, the upper lobed or deeply cut; the flower-heads 1 to 2 inches in diameter, lilac-purple. The outer florets are large. The heads resemble those of the Compositæ, but a brief study will show that there are only 4 stamens, and that they are free, not united to form an anther-tube, as in the flowers of that order. The other species, the **Devil's-bit Scabious** (*Scabiosa Succisa*), is easily distinguished from the above. It is 1 to 2 feet high; the leaves dark green, all entire, ovate or oblong, with scattered hairs; the flower-heads 1 inch across; the flowers deep purplish-blue, the outer ones being scarcely larger than the inner ones. The common name given to this plant is due to the rootstock being truncated, and having the appearance of being bitten off.

An orchid of quite a different type from those described in chapter xi. is the **Common Twayblade** (*Listera ovata*). The whole plant is green, and accordingly inconspicuous on the grassy slopes where it grows. It bears two opposite, simple, ovate, strongly-ribbed leaves, their size varying according to the situation of the plant. On the Braes they are usually 3 to 4 inches long, but one was found with leaves 6 inches long by 4 inches broad. The leaves are borne 5 or 6 inches from the ground, and beyond them a tall flower-shoot rises 6 to 9 inches long. The flowers are yellowish-green; the spur absent, and the lip or labellum strap-shaped, and deeply cleft into two lobes. The pollinia, separate in Orchis, are here connate with a common gland, and cleft longitudinally almost to the base. The pollen is yellow and mealy. Honey is secreted from a groove in the middle of the lip.

A grass, held in general favour, is the **Common Quaking-grass** (*Briza media*). It adorns the drier braes. It owes its attractiveness to its elegant panicles. The stems are 6 to 12 inches high. The spikelets are roundish, compressed, ¼-inch across, and pendulous from thread-like pedicels. The chaff-scales are concave, purplish, shining, with white margins.

The **Waved Hair-grass** (*Aira (Deschampsia) flexuosa*) is plentiful. It is a slender, erect plant, 12 to 18 inches in height, with the panicle 2 to 3 inches long, and the spikelets ¼-inch, yellow-brown, with purple. The axis and branches of the panicles are usually flexuose.

In damp places, especially in clayey soils, the **Tufted Hair-grass** (*A. (D.) cæspitosa*), already referred to on p. 70, is met with. This grass forms large, dense tufts. The stems are 2 to 4 feet high; the panicles 6 to 12 inches, and the spikelets one-fifth inch long.

An inconspicuous annual Crucifer, the dwarf specimens of which have a general resemblance to the Whitlow Grass, is the **Thale Cress** (*Sisymbrium (Arabis) Thaliana*). It is found on dry banks and on rocks where there is very little soil. Its radical leaves form a rosette. The stem is 3 to 9 inches high. The flowers are minute, white; the pods ½ to ¾-inch long, very narrow, and slightly curved.

The **Forget-me-not** (*Myosotis palustris*) is a perennial found in the muddy soil by the sides of streams. Its rootstock is creeping, and rooting at the joints; the stems 6 to 12 inches high; the leaves oblong, light green, somewhat glossy, glabrous or slightly hairy. The flowers are ⅓-inch across, sky-blue, with a yellow disc, and borne in the peculiar cymes whose spiral structure has led to the plant being also called a "Scorpion-grass." The Forget-me-not has long been held as an emblem of chivalrous affection.

A species occupying very dry ground is the **Early**

Scorpion-grass (*Myosotis collina*). It is an annual, 2 to 6 inches high, with hairy leaves, and its bright blue flowers are only $\frac{1}{8}$-inch in diameter.

A somewhat rare denizen of the marshes is the **Marsh Lousewort** (*Pedicularis palustris*). It is an annual plant of a very attractive appearance. The stem is erect, branched, a foot or more in height. The leaves are pinnate, with finely divided segments, glabrous, often dull purple. The flowers are borne in the axils of the upper leaves, forming leafy spikes. The calyx is oblong, with two broad, jagged lobes, and is inflated after flowering. The corolla is crimson, the upper lip compressed, with a blunt tooth on each side below the middle, and two minute teeth just below the apex.

Another marsh plant is the **Bog-bean** or **Buck-bean** (*Menyanthes trifoliata*). Its rhizomes are thick and creeping, with densely matted roots. The leaves are ternate, the leaflets obovate, 1 to 2 inches long, the petioles sheathing. The inflorescence is 6 to 12 inches high. The flowers are $\frac{2}{3}$-inch across, white, tinged externally with pink. The corolla is funnel-shaped, the lobes recurved, and thickly clothed inside with beautiful white filaments. The flowers resemble those of the Primrose in being dimorphic,—long-styled and short-styled. The Bog-bean is a member of the Gentian family.

In similar places the **Water Mint** (*Mentha aquatica*) is a very common plant. It is distinguished at once by its scent. The stems are square; the leaves ovate, serrate, hairy; the flowers in dense terminal spikes and axillary whorls, lilac or purplish.

The **Lesser Spearwort** (*Ranunculus Flammula*) is a very common marsh plant. The stem is hollow, decumbent at the base, and rooting at the joints. The leaves ovate- or linear-lanceolate, slightly toothed, and stalked. The flowers are $\frac{1}{2}$ an inch in diameter.

In many of the marshes, and by the sides of water-courses, the **Floating Meadow-grass** (*Glyceria fluitans*) occurs in abundance. Its leaves, $\frac{1}{4}$ to $\frac{1}{2}$ inch broad, and 6 to 12 inches long, float on the surface of the water. The stem is 1 to 3 feet high; the panicle slender, slightly branched, erect; the spikelets $\frac{1}{2}$ to $1\frac{1}{2}$ inch long, linear. This grass is often attacked by ergot.

The **Bladder Campion** (*Silene inflata*) occurs on the borders of fields, and the **Sea Campion** (*S. maritima*) amongst the shingle, or on the rocks at the shore. They are both characterised when in flower by the balloon-shaped, netted calyx, and the white, cleft petals. The flowers of the Bladder Campion form a many-flowered dichotomous cyme, while those of the Sea Campion are generally solitary. The leaves of the latter are much smaller and thicker than those of the former, a feature to be accounted for by environment. The Sea Campion is found by the sides of streams high up on our mountains. It is regarded by some authorities as merely a variety of the Bladder Campion.

In the salt marshes a very interesting series of plants occur. Many of them have already been described. On a shingly spot it may still be possible to see the maritime form of the **Scentless Mayweed** (*Matricaria inodora*). The type is a familiar field weed, with flower-heads resembling those of the Ox-eye Daisy. While the leaves of the field weed are cut into numerous short, slender, cylindrical segments, in the shore form they are shorter and more fleshy,—a feature associated, as we have already seen, with the presence of salt in the soil in which the plant grows. The latter form has been elevated to the rank of a species by some authorities, under the name of *Matricaria maritima*.

A Rush of very common occurrence—already referred to in chapter iv.—falls to be noted,—viz., the **Shining-**

The **Narrow-leaved** or **Common Cotton-grass** (*Eriophorum angustifolium*) occurs sparingly. It bears several sessile or stalked, drooping spikes, in a group on a stem a foot in height. The perianth is represented by bristles which elongate in the fruiting stage. When mature, the tufts of white, silvery, cotton-like down can be observed at a considerable distance. The down is sometimes used in stuffing cushions, etc.

The Carices include the following: the Lesser Common Sedge (*Carex acutiformis* or *C. paludosa*), Hairy S. (*C. hirta*), Distant or Loose S. (*C. distans*), Yellow S. (*C. flava*), Glaucous Heath S. (*C. glauca* or *C. flacca*), Carnation or Pink-leaved S. (*C. panicea*), Common S. (*C. Goodenowii* or *C. vulgaris*), Oval-spiked S. (*C. leporina* or *C. ovalis*), Prickly S. (*C. echinata* or *C. stellulata*), Great S. (*C. vulpina*), and the Flea Sedge (*C. pulicaris*).

The Distant Sedge and the Great Sedge have been described in chapter v. The **Prickly Sedge** is at once recognisable by the stellate arrangement of the groups of sharp-pointed fruits, and the **Flea Sedge** by the fruits being small, dark-brown, and shining.

Among flowering-plants of note on the Braes that, for want of space, have not been described, the following may be named: the Dog Violet (*Viola canina*), the Greater Stitchwort (*Stellaria Holostea*), Herb Robert (*Geranium Robertianum*), the Spring Vetch (*Vicia lathyroides*), the Silver-weed (*Potentilla Anserina*), the Meadow-sweet (*Spiræa Ulmaria*), and the Spear Thistle (*Cnicus lanceolatus*).

The British Ferns, popularly considered, are classified in two groups. One group is represented by the Moonwort and the Adder's-tongue,—forms so distinct in many respects, however, as to lead systematists to exclude them altogether from the Ferns proper (Filices). Of six Natural Orders constituting the Filices, three are represented in Britain,—one by the Royal Fern, a second by the Filmy Ferns, and the third by all the rest of the British Ferns (Polypodiaceæ). As already indicated, the Ferns bear on their leaves sporangia or spore-capsules in groups or masses, which vary in position, shape, and extent. In some instances the sori, as the groups are called, are naked, but usually they are covered by an indusium. This body is most commonly an outgrowth from the leaf, but in some ferns—the Bracken, for instance—the leaf itself folds over at the edge, and acts as a protection for the sporangia. The spores are extremely minute bodies, and their lightness enables them to be carried great distances by the wind.

The **Bracken** (*Pteris aquilina*) is familiar to everybody. In summer it forms a green mantle over very large tracts of the Braes. It is a plant of singularly aggressive habits. It persists and spreads by means of strong, horizontal, underground stems which penetrate to a very considerable depth. The rhizomes are externally very dark brown, and in section are of interest on account of the peculiar marks, due to the arrangement of the vascular and strengthening tissues. The corresponding tissues at the base of the leaf-stalk present the appearance suggesting the form of a spread eagle or an oak tree. The rhizomes contain a large quantity of starch, and have occasionally been used as food. Strong, upright, brittle leaf-stalks arise separately from the branches of the rhizomes at the end of May, and by-and-by the pinnæ unfold. Here the leaves are seldom more than 3 or 4 feet high, but in some parts of the country they attain to a much greater height. The leaves are triangular, divided into 2 or 3 coriaceous, deeply-cut pinnæ. As already mentioned, the sporangia form a continuous line along the margin of the underside of the pinnules, and are covered by reflexed membranous expansions of the leaf-margin.

Nectar-secreting glands exist at the base of the leaf-branches. They are active when the leaves are young, and are then visited by ants. When the leaves die they assume in their decay a very rich red-brown, spreading a warm tint over the Braes, which lasts through the winter. The colour is richest when the dead leaves are wetted by rain. The Bracken is found in all temperate regions of the world, and also in the Tropics.

While the Bracken has seldom been known by any other botanical name than that given above, the **Male Fern** has been the subject of kaleidoscopic nomenclature. I have known it as *Lastrea*, *Nephrodium*, and *Aspidium*, and now it is a choice between the old term *Lastrea* and an older one, *Dryopteris*. Early association leads me to prefer the former, and name the fern *Lastrea Filix-mas*. The stem is stout, 6 inches or more in length, decumbent, or obliquely raised from the ground. It tapers downwards, and the lower part is sunk in the earth, where it is held in position by the wiry roots. It is covered throughout with the persistent, fibrous bases of old leaves. The leaves are of annual duration, and are borne in a nest-like whorl. The centre of the crown is occupied by leaves in bud, thickly protected by scales similar to those which clothe the bases of the fully-grown ones. Their unfolding resembles the unwinding of a spiral. The fully-grown leaves are lanceolate, pinnate; the pinnules oblong, blunt, and serrate. The sori form a single line on each side of the midvein of the pinnule, each sorus being placed over a veinlet. The indusium is kidney-shaped, firm, at first white, later lead-coloured. The Male Fern very seldom produces branches.

The **Broad Shield Fern** (*Lastrea dilatata*) is of common occurrence. It is very variable, and the younger and dwarfer forms are apt to puzzle the beginner. This fern when full grown is readily distinguished from

enthusiastic search. It occupies narrow chinks in rocks facing the sea, where it is protected from severe frost. The leaves are in some cases 6 to 7 inches long, and 1¼ inch broad, but usually they are smaller. They are leathery and evergreen. The pinnæ are ovate-lanceolate, broad, and oblique at the base, the basal half of the stem dark red-brown. The rarity of this interesting plant constitutes a sufficient plea for its preservation.

A fern of extreme rarity on the cliffs is the **Maidenhair Spleenwort** (*A. Trichomanes*). I myself have only seen one or two small plants of it.

The **Hard Fern** (*Blechnum Spicant*) is abundant in somewhat moist places. Its sterile leaves are tufted, spreading, narrow-lanceolate, and pinnate. They are evergreen, and usually 6 to 12 inches long. In summer, there arise from the crown a series of spore-bearing leaves. They are erect, tall, and appear skeletonised, owing to the pinnæ being entirely occupied by the linear sori,—one on each side of the midvein.

Another familiar fern is the **Common Polypody** (*Polypodium vulgare*). It grows on rocky banks and elsewhere. The stem is creeping, and covered with chaffy scales. The leaves are pinnate, 4 to 8 inches long, and 1½ to 2 inches broad. The sori occur as two rows of circular clusters of golden sporangia, and they are peculiar in being destitute of indusia.

It may be mentioned that the **Brittle Bladder-fern** (*Cystopteris fragilis*) occurs on the cliffs, but it is very difficult to find.

The **Whale Rock** (Plate XII., fig. 8) is, or used to be, one of the richest botanical spots on the coast. It differs from the Maiden Rock, and the Rock and Spindle also, in being covered in certain places with a fair amount of soil. That soil, being derived from the "rotten rock," is not without ingredients of plant food. Further, the Rock is quite inaccessible to stock, which have, of course, been the chief agents in the destruction of the original flora of a greater part of the Braes. It was my privilege to give some account of the flora of this Rock when, as Lecturer in Botany in the University of St. Andrews, I delivered a public inaugural address. The list of plants enumerated on that occasion included nearly 60 flowering-plants and over 30 flowerless ones. The rarer flowering-plants present—*e.g.*, the Bloody Geranium, the Burnet Rose, the Thale Cress, and others—have already been described.

The Mosses recorded were the following: *Hylocomium triquetrum*, *H. squarrosum*, *Hypnum cupressiforme*, *H. Schreberi*, *Eurhynchium prælongum*, *Brachythecium purum*, *Pleuropus sericeus*, *Mnium undulatum*, *Tortula subulata*, *Grimmia maritima*, *G. pulvinata*, and *Dicranum scoparium*.

The Lichens included examples of *Lecanora*, *Physcia*, *Peltigera*, *Cladonia*, and *Ramalina*. Reference has previously been made to *Peltigera canina* and *Cladonia pyxidata*. *Ramalina scopulorum* (see Plate XI., fig. 5) is only found on the rocks at the shore, where it occurs in great abundance. It bears a remote resemblance to the so-called Reindeer Moss, a lichen referred to in chapter iv. It is much branched, the branches compressed, and greenish-grey. Numerous small cups are borne in a scattered fashion on the branches. Examined with the microscope, the cups are seen to be the spore-bearing part of the fungus which is one of the two constituents of the dual organism—the lichen,—the other being the alga.

A few hundred yards farther on, we cross the mouth of a glen, in the bottom of which a small streamlet runs to the sea. The name given to this fine ravine is **Kittock's Den.** The lower part (Plate XII., fig. 6) is visible from the shore, but the upper part is hidden, where it turns abruptly eastwards, and runs parallel with the coast. The upper end is near the village of Boarhills. It has been pointed out that the extent and depth of the Den suggest the action of a much larger and longer stream than that which occupies it now.

The cliffs at the mouth of Kittock's Den are particularly high, and being well clad with verdure, of which Bracken forms an important part, they are unusually picturesque (Plate XII., fig. 7). The prospect to the east is barred by the bold headland, Buddo Ness. Some distance beyond the Ness we reach an isolated mass of sandstone of great dimensions, and of peculiar outline (Plate XII., fig. 5), named the **Buddo Rock.** This mass is cleft across from top to bottom. An accumulation of earth and stones occupies the bottom of the cleft, and aids in the ascent to the top. The last part of the ascent is accomplished by means of steps cut alternately in the opposite walls. The top is covered with turf. A further feature of interest is to be noted when we pass to the eastern corner (Plate XII., fig. 4). There a mass of sandstone, shaped like an inverted cone, stands on a very small foundation, formed of the apex of the cone. This foundation, meagre as it is, is itself pierced at its base. The mass is fixed at its highest and broadest part to the body of the rock by a strip of sandstone of no great thickness.

Our route has lain through a region which the naturalist finds to be ideal in many respects. In appreciation of this, I have taken the liberty of recalling by illustration (Plate XII., fig. 9) one of the pleasantest of many outings made by the East of Fife Teachers' Field Club, a Club formed as a sequel to a course of Nature Study I had the honour of conducting in St. Andrews in 1901-02.

PLATE XIII.

FIG.

1. The Kinness Burn near the Shore Bridge.
2. Clavaria, amongst dead leaves.
3. The Kinness Burn at Abbey Park, with Common Reed.
4. *Xylaria hypoxylon.*
5. Capsule-bearing inflorescence of Knotted Figwort.
6. *Rissoæ* in clay.
7. Curly Pondweed (*Potamogeton crispus*).
8. Lesser Celandine (*Ranunculus Ficaria*)—root system.
9. Lesser Celandine leaf, with parasitic fungus, *Puccinia.*
10. Part of Sycamore leaf, with parasitic fungus, *Rhytisma.*
11. Butter-bur in flower at the Lade Braes.
12. Valley of the Kinness from Greenside Nursery.

PLATE XIII.

British seas, and is considered a characteristic shell of the glacial deposits of Scotland." Referring to the position of the clay, Mr. Walker observes that, "from the thickness of this clay, it is evident that a considerable portion of it must be many feet below the sea-level. It would likewise appear to have been deposited in a hollow scooped out of the boulder-clay. The latter can be seen a little farther down the stream, extending apparently from beneath the blue clay to the East Sands."

Inspection of the Kinness clay shows that it is traversed by layers of very small shells of a quite familiar kind, namely, *Rissoa ulvæ* (Plate XIII., fig. 6),—the same univalve as is seen in drifted masses on the surface of the mud at the salt-grass flats of the estuary of the Eden. The leaves of hardwood trees, fairly well preserved, occur in abundance; and it is certainly a remarkable coincidence to see the present season's leaves of the same kinds of trees floating past, while we are busy with the spade unearthing those that have lain in the clay for unmeasured centuries. Besides leaves, a considerable variety of seeds are found, one bearing a long awn being extremely abundant. A moss resembling *Hylocomium splendens*, but not yet identified, was also got.

Near at hand, on the north side of the Burn, stands Abbey Park, the house occupied by Dr. Robert Chambers when he was engaged in writing his notable work, 'Vestiges of Creation.' In the prospect from Abbey Park, the "ancient sea margins" in the valley of the Kinness, of which that author also wrote, are unmistakably outlined. The illustration (Plate XIII., fig. 12), taken from a point in Greenside Nursery, near the top of the avenue which leads to Abbey Park, shows the level lines of more than one of those terraces. The terraces have been denuded by certain small streamlets, and by the Kinness Burn itself, but the continuations of the levels are easily traceable.

From this point, too, we observe the fine example of the "crag-and-tail" formation of Wester Balrymonth Hill,—the western side steep, and the eastern a long slope seawards, recalling times past when glaciers with their burden of clay, gravel, and boulders moved slowly and majestically down to the sea. The distant peak in the west is Drumcarro Craig.

Opposite Abbey Park the Burn is encroached on by a patch of the Common Reed (*Phragmites communis*) (Plate XIII., fig. 3). When, a short distance farther up the stream, excavations were made for the foundations of the Boys' Brigade Hall, I found that the blue clay of the burn-edge extended to the site, and that it in some parts was filled with the remains of this reed in a wonderfully fresh state of preservation. It is interesting to think that the grasses which wave and rustle at Abbey Park are in all probability the direct descendants of plants which grew by the side of the stream when, long ago, it occupied a much wider channel. Besides the reed, I found there a hazel nut, various seeds, and the wing-case of a small beetle. The ground at the Hall is now too high to be inundated by spates, but the low-lying fields near by are still occasionally under water.

A few yards to the west of the Boys' Brigade Hall, Professor James Gregory's Meridian Line passes overhead. Professor Gregory was a mathematician of note, a friend of Newton, and the inventor of the reflecting telescope. For the purpose of carrying on his observations he took means of projecting a line from one of the windows in the Upper Library Hall to a point on Scooniehill, due south from the window and about two miles distant. This point is now indicated by a stone pillar. The shaft of the pillar is 9 feet 3 inches long and 12 inches square at the base, and it is fixed into the centre of a slab of very coarse conglomerate, shaped like a millstone. The slab rests on a brick base 14 inches deep. A three-pronged iron bracket, 3 feet high, is fixed to the top of the shaft, and each prong is terminated by a circular eye. The present bracket was preceded by one of similar pattern, and my recollection is that its lateral arms ended in crescentic hooks. I am indebted to Mr. J. Maitland Anderson for directing my attention to records referring to the Meridian Line. The present pillar must be comparatively modern. In the Minutes of the University dated March 17, 1775, the following entry occurs: "It was represented to the meeting that the two poles that were set up on the top of the hill south from the town for the meridians of the telescope and transit instrument are fail'd and frequently beat down by the wind, and that it would be proper two stone pillars should be set up in their place." This injunction was carried out, the account for the work being as follows: "William Neish, mason, for setting up stone pillars for the meridian marks—£2." Grierson, in 'Delineations of St. Andrews' (first ed., 1807), states that the meridian line was "determined toward the south by one of two large stone pillars of a conical form, erected on the height of Scoonie-hill, within view of the town, and on the north, by a small iron cross, to be seen on the west end of the house at present possessed by the principal of the United College." Mr. Maitland Anderson points out that the finely-cut line to be seen in the floor of the Upper Library Hall cannot have been made by the astronomer, because a new floor has been laid since his time; and further, that the south window through which observations were made has been rebuilt. In that case, if the triangular bracket attached to the side of the window is a part of Professor Gregory's apparatus, it is not now in its original position. The present pillar was quite visible from the town before the shelter-belt of trees was planted at Scooniehill.

pollination is effected by insects. This Mallow harbours the fungus, *Puccinia malvacearum*, which is the cause of the Hollyhock Rust,—a disease which for many years has rendered the cultivation of the Hollyhock a failure. It is stated that the wild Mallows have been inoculated with the Rust from the smitten Hollyhocks,—the fungus, like these showy garden plants themselves, being a foreigner.

The bank of the Burn, at the foot of the Cockshaugh, used to be a station for **Clary or Wild Sage** (*Salvia Verbenaca*), but the plant is now exterminated. I have specimens in my own herbarium, gathered in 1879, and the botanist who showed me where to get these gathered his specimen, also in my possession, many years before that date. I have further reason for remembering this plant. When filling the beds of the University Botanic Garden with species, I brought a piece, and duly planted it in the bed labelled Labiatæ. This I had cause to regret, for in the rich soil—as rich as any in St. Andrews—that formed the garden the plant knew no bounds, and made its way across the grass paths, when I was forced to eradicate it as a weed.

We pass a thicket of Sloes at the burnside, and soon reach a marshy corner (Plate XIII., fig. 11) clothed in the summer with the broad leaves of the **Butter-bur** (*Petasites vulgaris* or *P. ovatus*). The leaves are not unlike rhubarb. It is singular how very few people have noticed the flowers of the Butter-bur. They appear before the leaves in spring, and their colour is so similar to the surroundings that they are apt to be missed by all but the naturalist. They are not unlike the racemes of the garden hyacinth, but the place of the single flowers of that plant is here taken by capitula of many minute ones. The species is interesting in having two forms of flowers—the male and female,—and they are usually produced by different plants. The capitula of the latter are larger, and borne in denser racemes. The Butter-bur has spread very much since I was first taught to look for it at this place. It may be mentioned that a near ally of the Butter-bur, the **Winter Heliotrope** (*Petasites fragrans*), grows close to the old bridge at the Law Mill (see Frontispiece). Its leaves are heart-shaped, and comparatively small. This species blooms occasionally, the flowers being white. Another species, the **White Coltsfoot** (*Petasites albus*), grows in the shrubberies at Strathtyrum. This plant bears a very close resemblance to the ordinary Butter-bur, but the flowers are white.

Occupying large parts of the edges of the Burn, and close to the water, is an aggressive plant, the **Hairy Willow-herb** (*Epilobium hirsutum*). The flowering-stems grow 3 or 4 feet high. The flowers are rose, $\frac{3}{4}$-inch in diameter. The root-stock is composed of fleshy, subterranean branches, which, when broken up by spates, propagate the plant very readily,—so readily, indeed, that this Willow-herb is now far too common at the Kinness Burn, and means should be taken to check its further spreading.

In the early spring the sides of the stream are bedecked with the bright, glistening yellow, star-shaped flowers of the **Lesser Celandine** (*Ranunculus Ficaria*), the earliest buttercup of the year. The leaves are reniform, cordate, bluntly toothed, and glossy green; the sepals usually 3; the petals 8 to 12, becoming bleached when they fade. The roots are remarkable, a considerable number of them forming elongated tubers, which become filled with starch (Plate XIII., fig. 8). When the Celandine grows under shade, it produces small tubers in the axils of its upper leaves, which, when the leaves wither, are detached, and carried by rain-water or other means to places where they find a suitable lodgment. This plant delights to grow in the alluvium left by spates.

Like many other flowering-plants, the Lesser Celandine has its parasites. Very often one finds the leaves taken possession of by an interesting fungus, which makes its presence known by producing clusters of minute cups on their lower side (Plate XIII., fig. 9). Under the lens the cups are pretty and interesting objects. The microscope shows that they contain spores. It is a singular circumstance that only half the life-course of the fungus is spent as a parasite of the Celandine. The other half is accomplished on the leaves of Meadow-grasses (*Poa*), whence the name of the fungus, *Uromyces poæ*. It may be mentioned that a fungus presenting a very similar appearance is to be seen any summer day on the leaves of the Common Coltsfoot (*Tussilago Farfara*). In this case the complementary host-plant is also a Meadow-grass, and the parasite is called *Puccinia poarum*.

Amongst parasitic fungi there is one to be found on the leaves of almost every Sycamore (*Acer Pseudoplatanus*). It is named *Rhytisma acerinum*. It forms spots not unlike smears of dry pitch (Plate XIII., fig. 10). When the leaves fall, the inky spots do not rot so readily as the normal tissue of the leaf. If they are examined in the winter or early spring, they will be seen to be traversed by minute cracks. Microscopic inspection reveals that the cracks afford exit for spores which lie in sacs beneath. The spores are shot from the sacs, and are carried to the young leaves of the Sycamore, where they grow and by-and-by form the black masses of fungus tissue. It is a remarkable fact that the leaves of the Norway Maple (*Acer platanoides*), growing beside the Sycamore, are not attacked.

The abandoned whinstone quarry on the south side of the Burn, opposite New Mill, and at present used as a Rifle Club range, is noteworthy. The dolerite dyke, of which it forms a part, has been traced from Kittock's Den, past Balmungo, to New Mill, where it crosses the Burn.

Another interesting aquatic plant is the **Horned Pondweed** (*Zannichellia palustris*). The whole plant is submerged. The stem is filiform, branched, and rooting in the mud at the lower joints. The leaves are 1 to 2 inches long, finely linear, with membranous stipules. The flowers are very minute. As in the case of its relative, the Grass-wrack, pollination is effected under water.

The **Amphibious Persicaria** (*Polygonum amphibium*) is found at the edge of the pond, rooting in the mud. Its leaves float on the surface of the water. They are long-stalked, oblong, glabrous, with sheathing, hairless stipules. The flowers are bright rose, and borne in solitary, cylindrical spikes, erect, 1 to 2 inches long. They are dimorphic. A terrestrial form of this species occurs on somewhat damp ground. Its leaves are narrow-lanceolate, with short stalks, and rough with rigid hairs.

Rushes are found in abundance at various places on the Lade Braes, the largest patch being beneath Balnacarron, where the Common Rush and the Hard Rush grow in company. It is a highly interesting fact that the prehistoric—probably bronze age—inhabitants of the Kinness Valley found an æsthetic use for the Rush. A portion of a beaker urn which, along with a remarkable jet necklace, I found at Balnacarron in 1907, was seen to be decorated with horizontal lines made by plaiting rushes, and pressing the cord into the soft clay. A lucid and finely illustrated account of the discoveries in question has been published by Dr. Hay Fleming, in the 'Proceedings of the Society of Antiquaries of Scotland,' vol. xli. In that account, opportunity has been taken of recalling the discovery by Mr. C. Howie, fifty years ago, in the same field, of the remarkable series of cinerary urns now in a case in the vestibule of the Hall of the United College.

In damp places the **Water Avens** (*Geum rivale*) is plentiful. The drooping, purple-brown flowers, 1 inch across, and borne on a stem about 2 feet in height, cannot be mistaken. The radical leaves are pinnate, the terminal leaflet being large, and often three-lobed. The fruits appear in a round head, raised on a stalk above the calyx. The achenes or fruitlets are awned, hairy, and hooked at the extremity. The hooked achenes of the Avens correspond to the seed-like achenes within the hip of the Rose, the Avens being a member of the Rose family. The **Wood Avens** (*G. urbanum*) occurs in drier places. The leaves are very like those of the Water Avens. The flowers are yellow, erect, $\frac{1}{2}$ to $\frac{3}{4}$ inch across. The head of fruitlets is sessile. Highly interesting plants, recognised as natural hybrids between the Wood Avens and the Water Avens, are found occasionally in the vicinity. They have been described under the name of *Geum intermedium*.

Another peculiar representative of the Rose family is **Agrimony** (*Agrimonia Eupatoria*). It is found on the dry slopes of the Lade Braes. Its stem is erect, 2 feet high, clothed with soft hairs. The leaves are 6 inches long, interruptedly pinnate; the leaflets hairy, deeply serrate. The inflorescence is a tall, spicate raceme, and the flowers are bright yellow, $\frac{3}{8}$-inch in diameter. In fruit the "calyx tube" or receptacle encloses the two achenes, and becomes covered towards the top with little hooks, which attach themselves to passing animals,—a means of dispersal of the seeds.

An ally of Agrimony, and a plant appearing less likely to be associated in any way with the Rose, is the **Common Lady's Mantle** (*Alchemilla vulgaris*). It is a familiar road-side plant. The leaves are reniform, plaited, and lobed, and are often seen forming a cup, which holds a glistening drop of rain or dew. The flowers appear in loose clusters. They are yellowish-green, $\frac{1}{8}$-inch across; the corolla absent; the calyx and epicalyx persistent; the stamens 4; the carpels 1 or 2, enclosed in the calyx-tube.

The **Red Campion** (*Lychnis dioica*) is very plentiful. It is a hairy plant, 2 feet in height, with ovate-lanceolate, opposite leaves, and red flowers, the petals being deeply cleft, and the calyx ovoid. In certain plants the flowers are staminate or male, and in others pistillate or female, the latter being the stouter plants. The flowers are open during the day, and are visited by bees. The **White Campion** (*L. alba*) is also common. The easiest means of distinguishing it is by the colour of the flower. The flowers open and become fragrant in the evening, when they are visited by moths. Hybrids between the two species are not of unusual occurrence. They are rather taller than the parents. Their flowers are rose-coloured. The flowers of the Campions are often full of dark-brown powder,—the spores of a fungus, *Ustilago antherarum*. The spores are developed in the anthers. The **Ragged Robin** (*Lychnis Flos-cuculi*) occurs in damp places. The leaves are viscid; the petals rose-coloured, and cleft into 4 very narrow lobes.

The **Crosswort** (*Galium Cruciata*), plentiful on sheltered slopes, is distinguished at once by its leaves, which are ovate, ½ to 1 inch long, hairy above and beneath, and placed in whorls of 4, on decumbent stems. The flowers are small, pale yellow, in axillary clusters. **Cleavers** (*G. Aparine*) is an interesting, although very common, annual weed. Its prickles enable it to scramble to the light, and the hooked bristles on the fruit aid the distribution of the seed most effectively.

The **Ground Ivy** (*Nepeta hederacea*) grows on dry banks. The stem is prostrate, rooting at the base; the flower-shoots ascending; the leaves roundish-reniform, deeply crenate; the flowers lipped, and purplish-blue. This plant, being a Labiate, is not related to the Common Ivy.

Two Hypericums, the **Common St. John's-wort**

The leaves are large, ternately bipinnate; their stalks hollow and polished; the sheaths of the upper leaves dilated; the stem erect, 2 to 4 feet high, thick and hollow, purplish; the umbels large; the flowers $\frac{1}{6}$-inch in diameter, white, with long stamens; the fruit $\frac{1}{6}$-inch long, with 4 lateral wings.

A plant of very striking appearance when in fruit is the **Branched Bur-reed** (*Sparganium ramosum*). It grows by the side of the Burn and in the Law Mill dam. It is 2 or 3 feet high. The leaves are Iris-like, broadly linear, triangular at the base, and usually rising higher than the inflorescence. The flower-heads are spherical and sessile, and consist of either staminate or pistillate flowers only,—the pistillate heads the lower and larger, 1 inch in diameter when in fruit, and bur-like.

In the winter one finds, after much of the vegetation is gone, that attractive objects may still be met with. One of these is the dead, capsule-bearing inflorescence of the **Knotted Figwort** (*Scrophularia nodosa*) (Plate XIII., fig. 5). The illustration shows this to be an object of beautiful design. From the central racemose axis there arise in succession branches which fork repeatedly. The Knotted Figwort luxuriates in moist places. It is 3 feet high; the stem acutely quadrangular, not winged, with nodose tubers at the base; the leaves acute. Another species, the **Water Figwort** (*S. aquatica*), also occurs. It is 4 feet high; the stem with 4 narrow wings, without tubers; the leaves obtuse. The flowers of the Figworts are small, $\frac{1}{3}$-inch across, lipped, reddish-brown. The stigma is mature before the anthers. The fifth stamen is rudimentary, but of considerable size. The flowers are visited by wasps.

The **Wood Sorrel** (*Oxalis Acetosella*) is plentiful in Law Mill Den. Fresh leaves may be found all the winter. They resemble clover leaves in being trifoliate, but they are more delicate in texture, and when pulled wilt very quickly. At night the leaflets droop and fall together—a means of protection against cold during "sleep"—and in strong sunlight a partial drooping helps to prevent undue transpiration. The flowers are white, with purple lines, and they are insect-fertilised. Their structure is very similar to those of the Geranium—an allied genus. Inconspicuous and greatly modified flowers, which fertilise themselves, also occur. The seeds have a peculiar mechanism for their expulsion. A fleshy, elastic, cup-like coat—the aril—turns outside-in with such suddenness and energy as to throw the seed to a very considerable distance. Exit for the seed is found through a slit in the wall of the capsule. The Wood Sorrel is believed by many to be the original Shamrock.

In certain parts of the Den we find, in the late autumn, peculiar club-like, pure white objects rising from the ground amongst the dead leaves (Plate XIII., fig. 2). Their form has led to their being named *Clavaria*. Species of more common occurrence than that illustrated are yellow, of which examples are abundant on the Links. The Clavarias are classed with the Mushrooms and Toadstools. The spores are borne on minute, slender pedicels, without protection, and the whole outer surface of the visible part of the fungus is occupied with them.

A very common fungus is to be seen on old stumps of trees in the Den and elsewhere (Plate XIII., fig. 4). It grows out of the wood, and seems from its texture to be a part of it, whence the name, *Xylaria hypoxylon*. It consists of numerous flat branches, in outline not unlike the antlers of a deer. These are black at the base, and snowy at the top. The top part bears white spores on the external surface, while the darker part beneath has dark spores enclosed in flask-shaped cavities, from which they are forcibly ejected into the air.

On similar stumps numerous examples of a somewhat leathery fungus are attached like brackets. Their upper surface is ornamented with wavy zones of several shades, and the lower is pierced with minute pores, within which the spores are borne on stalks. This fungus is appropriately named *Polyporus versicolor*.

The Grasses are well represented on the Lade Braes. They include the Reed Canary-grass (*Phalaris arundinacea*), the False Oat-grass (*Arrhenatherum avenaceum*), Cock's-foot (*Dactylis glomerata*), and the Rough Meadow-grass (*Poa trivialis*).

Other flowering-plants to be met with besides those described already in previous chapters are the following: the Yellow Rocket or Winter Cress (*Barbarea vulgaris*), the Hedge Mustard (*Sisymbrium officinale*), the Meadow Vetchling (*Lathyrus pratensis*), the Tufted Vetch (*Vicia Cracca*), the Marsh Willow-herb (*Epilobium palustre*), the Ox-eye Daisy (*Chrysanthemum Leucanthemum*), the Common Burdock (*Arctium Lappa*), the Germander Speedwell (*Veronica Chamædrys*), the Self-heal (*Prunella vulgaris*), and the Common Bugle (*Ajuga reptans*).

The tributaries of the Kinness afford fields for very profitable wanderings. In the old Cairnsmill reservoir, which once was expected to hold water sufficient to supply St. Andrews for a long period, there is a colony of the Water Plantain (*Alisma Plantago*), noted for its finely shaped leaves and its tall, whorled panicles of flowers.

A very interesting geological object is to be seen in Lumbo Den, in the form of a large boulder of conglomerate or pudding-stone. No such rock is found native in this part of Fife, and—the traditionary giant notwithstanding—the only vehicle that could be imagined capable of carrying the boulder and depositing it there is ice.

PLATE XIV.

Fig.

1. Slime-fungus (*Leocarpus fragilis*).
2. Basaltic columns at Drumcarro Craig: Nature Study Class in the foreground.
3. Douglas Firs and Redwoods in California.
4. Cones of the Douglas Fir.
5. Spruce Gall, produced by Aphis.
6. Fossil fishes in Old Red Sandstone slab from Dura Den.
7. Common Spangle Gall of Oak.
8. Cones of *Sequoia gigantea*.
9. House constructed of the bark of *Sequoia gigantea*.

PLATE XIV.

Prior Muir is of another kind. Bog-mosses do not take part in its upbuilding, or only to a limited extent, but terrestrial plants, such as heaths, ferns, and grasses. The resultant soil is a comparatively open, brown, fibrous, elastic mass. Here and there various blends of soil occur, in which peat is more or less predominant; and it forms a highly recreative exercise to note the different kinds of vegetation which flourish in the several regions.

If a visit is made to the bit of moor on the north side of the railway, it will be found considerably curtailed in recent years by quarrying operations; but very much to interest the naturalist still remains.

A little gem of the Links and moors is here,—the **Milkwort** (*Polygala vulgaris*). It is a perennial plant, with a short, tough, woody stem, bearing branches, 4 to 6 inches long. The leaves are linear-lanceolate, ½ to 1 inch long. The flowers are borne in terminal racemes, and are blue, purple, pink, white, or intermediate blendings of these colours. Two of the sepals are enlarged and petal-like, forming the "wings." The lowest petal, named the "keel," bears a fringe-like crest at its apex,—which is often white when the rest of the flower is coloured,—and encloses the stamens and pistil.

The **Tormentil** (*Potentilla Tormentilla* or *P. erecta*) is a common moorland plant. The rootstock is stout, woody, almost tuberous, and from it spring erect or procumbent stems, 6 to 10 inches long, not rooting at the joints. The radical leaves are cut into 3, or sometimes 5, wedge-shaped, toothed leaflets; the upper leaves sessile; the flowers ½-inch across; the petals 4, rarely 5, yellow. The rootstock has for centuries been held to be of medicinal value. It contains an unusually large proportion of tannin.

The **Sneezewort** (*Achillea Ptarmica*) is a perennial Composite, growing in somewhat moist places. The stem is 2 to 3 feet high; the leaves 2 to 3 inches long, broadly linear, and regularly and sharply serrate; the flower-heads few, in loose flat-topped corymbs, ½-inch or more in diameter; the disc-florets greenish-white, and the ray florets white. Yarrow or Milfoil (*Achillea Millefolium*) is of very common occurrence in pastures and by waysides. It is at once distinguished from the Sneezewort by its leaves being cut into numerous very fine segments, and its flower-heads being many and borne in dense corymbs.

The **Bog Asphodel** (*Narthecium ossifragum*) is a plant with foliage like a miniature Flag Iris. The root-stock is a creeping rhizome; the leaves 6 to 12 inches long, in two ranks, rigid, strongly-ribbed; the flower-stem 8 to 10 inches high; the flowers in a raceme, bright-yellow above, green below, ½-inch across; the capsules pointed; the seeds very minute, with a thread-like appendage at each end.

The **Eyebright** (*Euphrasia officinalis*) is an annual, growing in patches in dry grassy places. It is a slender, branching plant, 3 to 4 inches in height; the leaves opposite, sessile, ovate, ¼- to ½-inch long, toothed; the flowers in terminal spikes, with leafy bracts; the corolla ⅓-inch across, pale lilac, with purple veins; the middle of the lower lip yellow. This species is very variable, and some authorities believe that in place of there being only one species so called, over a dozen can be distinguished.

Allied to the Eyebright is the **Red Bartsia** (*Bartsia Odontites*). It is also an annual. The stem is 6 to 12 inches high, erect, wiry, much branched; the leaves ½ to 1½ inch long, lanceolate, distantly toothed; the flowers in one-sided panicled spikes; the corolla ½-inch long, red.

Another relative of the Eyebright is the **Common Yellow-rattle** (*Rhinanthus Crista-galli*). It grows in damper places, and is annual. The stem is erect, rigid, 4-sided, 6 to 12 inches, simple or branching; the leaves opposite, sessile, lanceolate, deeply toothed, 1 to 2 inches long; the flowers axillary, in a lax, leafy spike; the corolla ½ to 1 inch long, yellow, the upper lip with two violet lobes; the calyx inflated, becoming bladder-like, and enclosing the orbicular, flattened capsule. Eyebright, Bartsia, and Yellow-rattle are all semi-parasitic, some of the roots being attached to the roots of grasses.

The sides of the old quarries are rendered gorgeous in summer by the profusion of the **Common Broom** (*Cytisus scoparius*). The roots are well provided with the gall-like tubercles—common to most Leguminosæ—in which a peculiar race of fungi, resembling bacteria, find shelter and sustenance. By way of compensation, these organisms not only pass to the host plant pabulum peculiarly rich in nitrogen,—the atmospheric nitrogen being appropriated by them,—but also by their decay return this element to the soil in added quantity. The leaves are very small, and the branches are switch-like, wiry, furrowed, and bright green,—a condition of things which shows that the plant has occasion, like its neighbour, the Whin, to guard against undue loss by transpiration; whilst the development of abundant chlorophyll in the branches is the means of making good the lack of leaf-surface. The flowers exhibit a particularly interesting explosive mechanism. This may be seen in active operation when a bee alights on a flower,—or by imitating its action. The keel in the undisturbed flower is sealed, and encloses the stamens and pistil. The movement of the bee has the effect of opening the upper edge of the keel, at the base, and the short stamens lying there suddenly spring through the slit and dust the lower surface of the insect with pollen. If further pressure is applied by the bee, the split reaches the tip of the keel, and the style, which had been lying there in a coiled form under tension, springs up with considerable violence, causing the stigma to strike the back of the bee, followed instantly by the deposit at the same place

highly interesting phenomenon exhibited by this and certain other species of Rush, and also by certain grasses, cereals, and other plants, is the bursting into full flower suddenly and simultaneously of all the plants in the district, without any well-defined or explicable cause. It is sometimes observed to occur immediately before heavy rain.

The **Scaly-stalked Club-rush** or **Deer's Grass** (*Scirpus cæspitosus*) is also plentiful. It grows in very dense tufts. The roots are tough; the stems 8 inches high, wiry, covered at the base with a mat of persistent brown sheaths; the uppermost sheathing leaves with free blades, ¼- to ½-inch long; the spikelets solitary, terminal, ovate, three-fifths inch long.

The **Mat Grass** (*Nardus stricta*), a plant previously mentioned, presents tufts similar to those of the Scaly-stalked Club-rush, but the stems—which follow each other closely in series in one direction on the rhizomes—are clothed in colourless (white or grey) sheaths. Many of the setose blades project at right angles from the sheaths.

The **Round-headed Sedge** (*Carex pilulifera*) grows in dense tufts. The leaves are bright green and grassy. On the top of a stalk, 9 to 12 inches long, there is a group of 3 female spikes placed close beneath 1 narrow apical male spike, the latter being at most ½-inch long. The stem is arched at the fruiting stage.

Besides the flowering-plants, there is always much among cryptogams on a moor, however small, to attract the naturalist's notice. The **Common Hair Moss** (*Polytrichum commune*) is a case in point. It forms dense patches, 6 to 12 inches high. The stem is wiry, and the leaves linear and pointed. The fruit is unmistakable, the capsule being quadrangular, and completely covered by an extinguisher-like cap of golden silky hairs.

One of the Bog-mosses, *Sphagnum compactum*, is very abundant. It forms dense, pale-green cushions, a foot or less in diameter. In the late autumn it is found bearing minute spherical capsules like seeds, at the apex of several of its stems.

The fungus family is largely represented. By far the most conspicuous fungus is the **Fly Mushroom** (*Agaricus (Amanita) muscarius*). It grows amongst the fallen pine needles in the small plantation. The cap is 4 to 6 inches in diameter, borne on a stem 6 to 8 inches high, and is brilliant scarlet, with yellowish warts scattered over the surface. The warts are the remains of the veil, the basal part of which forms a sheath round the stalk. The spores form a chalk-white deposit when the cap is cut off and laid down with the gills resting on a sheet of paper.

Another very brightly coloured fungus is the **Emetic Russule** (*Russula emetica*). In this case the cap is 2 to 3 inches in diameter, and rose-pink,—the colour contrasting vividly with the white of the gills and stalk. This fungus is considered dangerous. The spores are white.

Along with the above there occur a number of fungi which, when pierced, exude a milky juice, whence the name, *Lactarius*, given to the group. It is unsafe to use the milky species.

The **Clustered Yellow Mushroom** (*Agaricus (Hypholoma) fascicularis*) is one of the commonest of fungi. It grows on old stumps and on fallen trunks in crowded clumps. The cap is 1 to 1½ inch in diameter, sulphur yellow, and reddish-brown on the top. The spores are purplish-brown. It is regarded as poisonous. The odour is nauseous.

Witches' Butter (*Tremella mesenterica*), a very peculiar fungus, grows on the dead stems of the Whin, where it appears as scattered elongated patches of tremulous orange-yellow jelly. It is horny when dry, but gelatinous again when moistened. In the above fungi the spores are borne externally on processes called basidia, whence the term Basidiomycetes given to the group.

On soft, sandy, and somewhat peaty ground, where rabbits have been burrowing, fungi of an entirely different form grow. They are cup-shaped, without stalks, globose at first, 1 to 3 inches across, buff externally, and waxy-brown internally. Under certain conditions, and often when one is kneeling and examining the plants closely, the spores are ejected as faint puffs of smoke from points in the floor of the cup, the phenomenon being similar to that seen in Ergot (p. 64). This species is named *Peziza vesiculosa*.

On the Larch trees near by, one sees small fungi bearing some resemblance to the Peziza just described. They are $\frac{1}{8}$-inch or more in diameter, white, with a reddish centre. The part of the stem bearing the cups is swollen, blackened, and cankered, with resin exuding from wounds. This fungus is the dreaded **Larch-blister** (*Peziza (Dasyscypha) Willkommii*).

The leaves of the Brambles on the Moor are, in the autumn, decorated on the upper surface with bright red spots. Inspection of the underside of a spotted portion shows the presence of specks, which the microscope resolves into the spores of a parasitic fungus, *Phragmidium*.

In certain of the Willows, *e.g.*, the Goat Willow (*Salix caprea*), the leaves bear on the under surface numerous spots and patches of bright yellow dust, which magnification enables us to detect as the spores of the Willow Rust (*Melampsora*).

A group of lowly organisms, the so-called **Slime-Fungi** (*Myxogastres* or *Myxomycetes*), is represented by one or two species. One day I gathered amongst the pine needles a small patch of white material that might have been mistaken for a piece of sodden bread flung on the ground. It was laid in a dry place, and in a few hours a

their full share of galls. The **Oak Marbles** or Marble Galls are very familiar objects. They bear a great resemblance to the brown marbles of the schoolboy's sport. The grub of the insect—*Cynips Kollari*—may be seen in the centre of the gall in summer and autumn.

Galls of an entirely different shape are to be found on the leaves of the Oak,—the **Common Spangle Gall** (Plate XIV., fig. 7)—tenanted by *Neuroterus lenticularis*. They are lenticular, and attached to the underside of the leaf, and they fall from the leaf in September or later.

Yet another Oak-gall is the **Silk-Button Spangle,** caused by *Neuroterus numismatis*. This gall is very small, but it is dainty, being glossy and golden brown.

A fourth gall on the Oak is the **Oak Apple.** It is exceedingly plentiful at Prior Muir. In summer it is not unlike a small, pink-tinted apple. Its rightful tenant is *Teras terminalis*, but very numerous inquilines (lodgers) and parasites are also found in the gall. An alternate agamous generation of Teras is the form called *Biorhiza aptera*, which is responsible for the Root Gall of the Oak. The other oak-gall builders described above have also other forms representing alternation of generations, but in their case it is the galls formed by the agamous insects that are the more familiar.

The Birch trees bear dense twiggy masses like rooks' nests, called Witches' Brooms. They are caused by the attack of a mite, *Eriophyes (Phytoptus) rudis*, which infests the buds.

Drumcarro Craig.

On our way to Drumcarro Craig we pass the fine estate of Mount Melville. Amongst the many fine conifers which grace the grounds, none is more interesting than the Californian **Mammoth Tree** (*Sequoia gigantea*). This tree shows, by the lighthouse-like conformation of its bole, that it is preparing to grow to a great height. In its native groves, on the western slopes of the Sierra Nevada, examples well over 300 feet high, with a trunk clear of branches to the height of nearly 100 feet, are recorded. The enormous bulk of the trunks of such trees may in a measure be realised by the illustration (Plate XIV., fig. 9), which shows a section of the bark used for the construction of a roomy house in the grounds of the Agricultural Department at Washington, D.C. The cones (Plate XIV., fig. 8) are small, being only 2 to 2½ inches long. They are borne freely by trees at Mount Melville and elsewhere in Scotland. This tree was accidentally discovered by a hunter. The date of its introduction into our country is 1853. It was at first named by an English authority *Wellingtonia*, but the Americans desired for it the designation *Washingtonia*. *Sequoia*, the name finally adopted, commemorates a Cherokee Indian chief of mixed blood, and known to his tribe as Sequoyah. This name had previously been applied to the only other living representative of the genus, the Californian Redwood (*Sequoia sempervirens*), a tree discovered by the Scottish botanist, Archibald Menzies, in 1795, but not introduced into England till 1846.

In the immediate vicinity of Denhead, limestone, coal, and ironstone occur. Fossils got in the Black-band strata there are to be seen in the University Museum. The lime quarries and mines are of very considerable extent. After a long interval, new ironstone workings have recently been opened.

Drumcarro Craig is the highest hill in the neighbourhood of St. Andrews, its summit being 714 feet above sea-level. It is 4 miles from the city. It presents a somewhat sharp ridge, and in this respect is different from the neighbouring hills seen from the city, which are all well rounded. The southern face of the Craig is being quarried for road metal. Its basaltic character is at once discernible (Plate XIV., fig. 2). The columns exposed are for the most part irregularly pentagonal. On the eastern side of the quarry they lie at an angle of about 30 degrees, and on the western side the angle is much higher. A feature of antiquarian interest is a prehistoric fort, the remains of which are traceable on the summit of the hill.

The view from the summit on a clear day is far finer than most people living in St. Andrews, and seeing little else than the Links, could imagine. Its range and attractiveness have been acclaimed by Principal Tulloch, Dr. A. K. H. Boyd, the Marquis of Bute, and others. The prospect is very extensive, especially northwards, where a great valley extends to the Forfarshire hills. To the east, St. Andrews is seen lying on a rocky promontory close to the sea, and beyond the city is the North Sea, with the Bell Rock Lighthouse just visible on the horizon. To the north the Banks of Tay—those treacherous accumulations of sand at the mouth of the river—have their position rendered visible by the surf that breaks over them. Nearer at hand, beyond the Links and the wide estuary of the Eden, Tents Muir lies like a carpet between the Eden and the Tay. Our eyes wander to the distance, and are arrested by the Sidlaw Hills, above the smoke of Dundee, and farther off by the Grampians, including the alpine botanist's paradise—Clova. The geographer, with map and compas, now finds practice in locating and recognising the mountains within sight. A little to the west of north, over Craigowl in the Sidlaws, towers Lochnagar, 47 miles off. Sweeping westwards we see in succession Ben-y-Gloe, Ben-y-vrackie, Schiehallion, Ben Lawers, Ben-chonzie, Ben-more, Ben Voirlich—due west 51 miles—and, a few degrees south, Ben Ledi, 56 miles off. In the near distance, to the south, lies Largo Law, an eminence which overlooks the Firth of Forth.

Wood Sanicle (*Sanicula europæa*), and other plants of interest.

On the high ground to the east of Dura Den the site of a so-called silver mine exists. The mineral which attracted attention was galena or sulphide of lead. It is recorded that the discovery was made in 1772. The vein was followed for some distance before operations were abandoned.

Dura Den.

When we reach Pitscottie Toll, where five roads intersect, we follow the road which runs northwards on the right bank of the Ceres Burn. This stream passes through Dura Den, and falls into the Eden at the bottom of the ravine. It may be mentioned that in the neighbourhood of the hamlet the Scottish historian, Robert Lindsay of Pitscottie, had his home. About 350 yards from Pitscottie Toll, and for a distance of over 400 yards, the stream runs over dolerite, a sill having invaded the Carboniferous strata there. Very soon a precipice of sandstone, massive, coarse-grained, and yellowish, is passed on the right. It is known as Charlie's Rock—a person of that name having, it is said, built a stable underneath an overhanging portion of the cliff. Beyond this the road skirts the Blebo Mills dam, and, at the Mills, dolerite is again visible. Thereafter the road rapidly descends, and near the foot of the hill it once more skirts the Burn edge. It is obvious from the appearance of the sandstones in the bed of the Burn, and, in a more striking way, in the high cliffs opposite Yoolfield Mill—now Dura Den Sawmill—that they are different from those seen at Charlie's Rock. For the first time in our excursions we are amongst the strata of the Old Red Sandstone. In this part of the ravine they are red or orange, fine in the grain, and very distinctly laminated. This system lies beneath the

Carboniferous, and is accordingly older. In the Den the two series do not exhibit conformability,—that is, uninterrupted superposition of the younger on the older,—a fault having cut out a part of the top of the Upper Old Red Sandstone and brought the Lower Carboniferous strata down. The fault crosses the Den in a diagonal direction, but the actual line of dislocation is not visible.

Dura Den has for three-quarters of a century been famous in the annals of geology as the repository of fossil fishes of the Old Red Sandstone period. The first announcement of the presence of fossil fishes in the neighbourhood was made by the Rev. Dr. John Fleming, a noted naturalist of his time, when, in a paper published in 1831, he made mention of the discovery of scales, described by him then as those of a vertebrated animal, probably a fish. They were found in a quarry at Drumdryan, to the westward of Dura Den. It is recorded that the piece of sandstone containing them was brought to Dr. Fleming by a student of St. Andrews University. The scales were ultimately identified as those of a Holoptychius.

About 1836 excavations for a water-course for a mill were made in the Den, a considerable height above the level of the Burn. The workmen at that time exposed slabs in which, along with certain undoubted fishes, fossils of "frog-like creatures," 3 inches or more in length, were found crowded together. The latter were at first supposed by the Rev. Dr. John Anderson, the naturalist into whose hands a portion of the slabs containing them fell, to belong to the insect family; but, as may be read in Hugh Miller's 'Old Red Sandstone,' that noted geologist regarded them as specimens of a fish. Agassiz recognised them as examples of a new species of the genus of fishes he had named Pterichthys, but later, owing to an error on the part of the great systematist, which had led him to change his mind, the organism was known for a time as *Pamphractus Andersoni*. So late as 1888, Dr. R. H. Traquair, from a renewed study made of Dr. Anderson's original slab, now deposited in the Edinburgh Museum, decided that the species "does not belong to Pterichthys after all, but is an unmistakable Bothriolepis" (*B. hydrophilus*). This genus is distinguished from Pterichthys in the paddle-like limbs being equal in length to, or longer than, the carapace, and by the absence of the scaly tail. It is suggested, however, that the tail may have existed, but, being unprovided with hard parts, had not been preserved. Bothriolepis is held to be one of the Ganoidei or Enamel-scaled Fishes. The most familiar of the living representatives of this order is the Sturgeon.

In what were probably the same excavations, when a mason was splitting a slab, an entire fossil fish "leaped into his hands." Dr. Anderson, in his work on Dura Den (1859), states that the specimen referred to was the first of the family Holoptychius to be figured, and it was named by Agassiz *Holoptychius Andersoni*. It is not specifically distinct from *H. Flemingii*. Mr. Robert Walker, in a paper on 'Fossil Fishes of Dura Den,' states that the name of the latter was founded by Agassiz on a piece of a fish which was found in the Den, he believed, by Dr. Fleming.

In 1842 Sir Charles Lyell visited the Den in company with Dr. Anderson. Investigation does not seem to have been actively pursued for a considerable period after that date, the next record showing an interval of sixteen years. "The 16th day of September, 1858," says Dr. Anderson, "will ever be memorable in the annals of Dura Den, when, in presence of Sir Roderick I. Murchison, Lord and Lady Kinnaird, and a distinguished party from Rossie Priory, the largest Holoptychius ever discovered was exhumed from the rock, in full and perfect outline and entireness, and measuring upwards of three feet in

The visitor to the Museum cannot but be impressed with strange sensations when he contemplates the yellow slabs with the carbonised forms huddled together in the attitudes in which they perished. In the picturesque defile of Dura Den he will scarcely be less impressed, although he may only see the sandstone strata in which companions innumerable of the fishes in the Museum no doubt still repose. The imagination is deeply stirred by the survey of the stony records of a great and sudden slaughter, and by the evidence—in cascade and precipice—that the stream in the Den has worn its channel down through deep masses of solid rock to the bed in which the fossils lie. But it is impossible to form the dimmest conception of the remoteness of the period when the fishes sported in their armoured pride in the lakes and land-locked bays where they found a congenial abode.

Our rambles are now ended. On our first excursion we set out from the United College, and it is fitting that our studies should terminate in the Museum there. Since we left the "College of the Scarlet Gown" we have, I trust, seen much on cliff and moor and by shore and stream that will remain as cherished memories. I cannot find more appropriate words with which to link good-bye than those used by our late Lord Rector, a native of the Kingdom of Fife, and a princely patron of research: "It is good for us to be here, and to have the heart stirred as St. Andrews alone can stir it."

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THE END.

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