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INDEX TO VOLUME IX. OF TRANSACTIONS (1929-38).

SUBJECTS.

AUTHORS.

I.—*Through The Dolomites.*

By Henry Coates, F.S.A. Scot.

(Abstract of Lecture delivered November 8, 1929).

The region known as "The Dolomites" lies between Austria on the North, Italy on the South, and Switzerland on the West. It forms part of the ancient Principality of the Tyrol, which has changed hands, politically, several times. Until the Great War it belonged to Austria, but in the course of that contest, after most desperate fighting in the mountains, the Southern portion of it was captured by the Italians. The traces of that Titanic struggle we saw at many points as we passed through the country.

The Dolomites, properly so-called, are a range of mountains forming part of the Eastern extension of the Alps. The name is derived from the rock of which they are composed, namely Dolomite, or Magnesian Limestone, which was first studied in this region by Monsieur le Comte de Dolomieu, a famous French Geologist of the eighteenth century. These rocks are of Triassic age, and organic origin. They have been derived from Coral reefs, and were probably ordinary limestones (Carbonate of lime) to begin with, which have been altered by the infiltration of water charged with Gypsum and other minerals. Dolomite occurs in many regions, but it is typically developed in the mountains of Bavaria and Northern Tyrol, where it occurs as a massive formation.

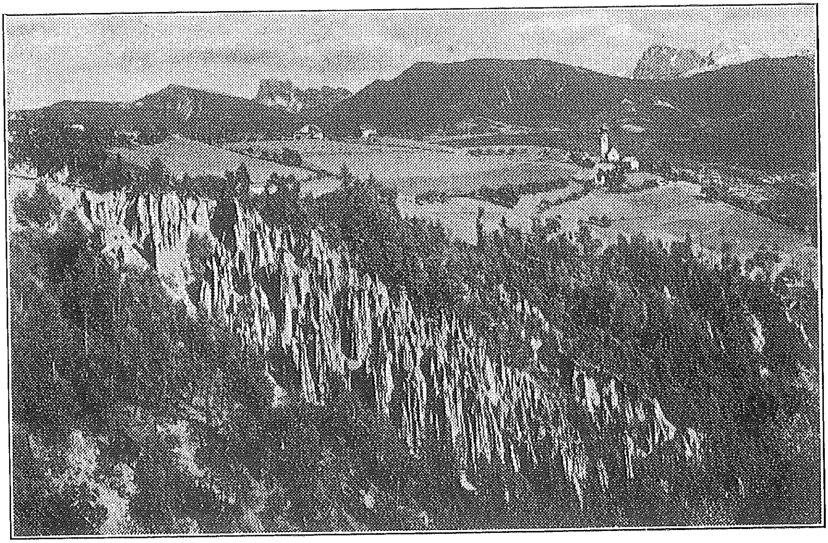
The Dolomite Range runs through Northern Tyrol from Dobbiacco in the North-East to Bolzano in the South-West, and comprises some of the most imposing mountain scenery in Europe. What is known as "The Great Dolomites Road," which was constructed by the Austrian Government for stategical purposes before the war, and took six years to build, is a marvel of engineering skill. It makes its way through apparently inaccessible mountains, climbing over pass after pass at heights approaching ten thousand feet, which it scales by scores of hair-pin bends. Where it cannot go over the summit, it bores its way through tunnels, or clings to edges of overhanging precipices.

It was along this Great Dolomites Road that we made our way through the mountains, starting from Innsbruck, the ancient capital of the Tyrol, and proceeding by the Brenner Pass to Dobbiaco and thence by Cortina in the Ampezzo Valley, the Falzarego, Pordoi, Karer and Stelvio Passes, to Bolzano. On the way we halted at a series of beautiful mountain lakes, including Misurina, Pragser-Wildsee and Karersee, and also Pieve di Cadore, the birthplace of Titian. From Bolzano we continued our tour by Merano and Tirano, and thence over the Bernina electric mountain railway to St Moritz, in the Engadine.

The most attractive feature of the Dolomite Mountains, apart from their rugged grandeur, is their wonderful colouring. Where they have been exposed to the action of the weather, the rocks take on the most vivid hues of red and yellow, streaked with blue-grey. Especially is this the case when seen by evening light, when the sun-lit peaks are relieved by deep purple shadows.

Many interesting geological features were observed in passing, such as the Earth Pillars in the Gorge of Rufidaum-Bach, near Bolzano; the Glacial Pot-holes at Maloja, in the Engadine; the Glacial Phenomena at Morteratch, in the same region, etc. Alpine flowers were in great profusion, especially on the hills around Cortina, where the fields seemed carpeted with blossoms of every shade of red, yellow and blue, forming natural Rock Gardens, many acres in extent. One of the most interesting species was the little purple *Soldanella*, which grows right at the very edge of the snow, through which the opening flowers in spring have the power of melting their way, by generating a minute degree of heat. Bird life was fairly abundant at many points on the route. Among the most characteristic species were the Redstart and the Black Redstart.

We had the pleasure of inspecting most excellently arranged Local Museums both at St. Moritz and at Zurich. The former is entirely devoted to the Folk-lore of the Engadine, while the latter, which is the Swiss National Museum, is designed to illustrate the history and antiquities of the various Swiss Cantons. What struck us particularly in both of these Museums was that the exhibits were displayed, not in large and dreary galleries, but in a series of comparatively small apartments, each of which was decorated and furnished in a style appropriate to the period represented. The consequence was that the eye was not fatigued by having to take in more ideas than the mind could assimilate at one time. This is a characteristic which might be adopted with advantage in many of the museums in this country. In Zurich we were much indebted to the secretary, Miss Lucie Egger, who, at the request of the Director, devoted the afternoon to explaining the exhibits to us.



Earth Pillars in the Gorge of the Rufindaun-Bach, near Bolzano.

PLATE I. [*Photo H. Coates.*

In Old Bormio.

PLATE II. [*Photo H. Coates.*

Monte Cristallo, Cortina.

PLATE III. [*Photo H. Coates.*

Lake Misurina, and the Drei Zinnen.

PLATE IV. [*Photo H. Coates.*

II.—*Climbing Among Scottish Mountains.*

By ALASTAIR L. CRAM.

(Read December 13, 1929).

It is particularly apposite that Members of a Natural Science Society should be interested in Mountaineering, since the interests of the climber and the scientist are so closely allied upon the mountains.

It is there that the latter finds objects of primary importance, in the especial branch of his labours. Rocks, alpine plants, wild life and weather conditions, all of the first importance to this Society, can be studied on the hills as nowhere else, and it is there, too, that the photographer revels among subjects of exceptional interest for the exercise of his skill.

Interests are not only paralleled but combined for he is a poor climber who is not interested in one or other of these pursuits, a knowledge of which adds so much interest to what otherwise might be a dull ascent, or a mere test of endurance and climbing skill.

On the other hand, even for his own personal safety, the scientist must know something of mountaineering, especially the ability to find his way off the hills through any of the vagaries of our uncertain weather.

Though mountaineering, as such, is still a comparatively young sport in Scotland, it is greatly to the credit of this Society that many years ago it formed a mountaineering club, possibly the only one of its kind in Scotland. On account of our central and northern situation, and our nearness and accessibility to the true Highlands, it is surely resting owing to us to show records of work and exploration among the hills, and it is earnestly to be hoped that the Society will continue to encourage and foster this fascinating and repaying branch of its activities.

The Science of Mountaineering is like all other sports in this, that it is not learnt in a day, and it is by a slow and natural progression that the humble pedestrian becomes a skilled climber.

I suppose nearly all climbers begin by hill-walking, drawn there in pursuit of some favourite pastime. At first they keep carefully to the obvious routes and then only in settled weather. At first they tend to despise the rock-climber as a reckless fool, being still disturbed with the emotions produced by the immensity in which they find themselves, and the very human sensation of fear at the unknown. But gradually they fall under the lure of the crags, and abandon the easiest ways for those that offer a more interesting and sporting route to the top.

By divergence from paths to trackless ways, from hill-slopes to rocks, from rocks to snow and ice, from being forced to route find in mist, from the necessity of getting off the hills in a snowstorm, for ascent to ascent, is the mountaineer evolved.

Thus it is from the ranks of our hill walkers and scientists that our great mountaineers are recruited, and many of those who have served their apprenticeship among our Scottish hills have made names for themselves on account of their exploration and discoveries abroad amongst higher ranges.

Scotland provides a splendid training ground for climbers. The gradual and natural processes of denudation have laid bare many widely differing formations, with the result that this country can offer an alluring assortment of rock which provides a wide choice of quality for the edification of the rock climber. I say denudation, expressly, for though we are in the habit of regarding Scotland as a mountainous or hilly country, in reality it is a dissected tableland, carved out of a solid block of extremely complex geological structure.

In this country the rock climber inevitably develops into a student of ice and snow, possibly because our hills are more interesting in their arctic condition and partly because those which are situated within the bounds of deer forests are more accessible during the winter and spring.

It is one of the charms of Scottish mountaineering that bad weather does not necessarily cause the abandonment of an expedition. It is possible for a competent party to make the ascent of almost any of the Scottish Mountains, with perfect safety, in any condition of weather. A ridge may be impracticable on account of the violence of the wind, or a rock climb may refuse to "go" when the holds are smothered in snow and ice, but there is usually some alternative route, by which these hindrances may be avoided. Hence one may arrange a mountaineering holiday in any given district, at any time of the year, with the assurance, that although plans may have to be modified and particular routes avoided, ascents will not be altogether out of the question.

There are, however, certain limitations. An inexperienced party may incur grave risks in very ordinary conditions of bad weather, where capable mountaineers would be safe in a blizzard. Mist, for example, is such a common experience, that a map and compass, and the ability to use them, should be in every party, even on the easiest mountain and in the most promising weather. Few realise the dire necessity for a compass. Without one the tourist resembles an aeronaut in the balloon; he has got up but it will be a difficult business to come down, while for the time he has no control over his movements. Those who were at the Society's Mountaineering Club excursion to Braeriach last August will remember with what ease and accuracy the compass took us off that mountain in the mist. Success and safety are attained by knowledge and proper precautions, failure and danger result from ignoring them. On the mountains it is hardly necessary to stress the necessity for care unduly. There is only one sort of mountaineer, and that is the safe one, for the others do not live long. Climbing is justifiable a thousand times over, but without incessant care and continual forethought for danger, and, above all, the strength of mind to turn back on a too hazardous ascent, climbing becomes an unjustifiable sport.

A holiday among the mountains not only benefits the body, but it is a tonic to the mind. It tears down all the hypocrisy that accumulates within us during our everyday life, it lifts us out of the narrow ruts of convention. It broadens the mental outlook and lets a breath of fresh air sweep away all the little spites, gossips, jealousies, disagreements and snobberies that daily afflict us all. We leave them behind in the valleys where little cares are great, we rise superior to them in the face of the mountains, and while we receive from them their lesson of calmness and eternal repose, we realise through the vastness of mere matter the enduring Spirit of God.

Indeed, one cannot go up into the hills without realising the constant presence of things spiritual. In their eternal Sabbath hush the mind dwells more and more upon things of the Spirit, and their infinity of space points to the infinity of the Spirit and drives home more effectively than any church or creed the existence of God.

This must be taken into consideration when comparing climbing with any other sport, that while it strengthens the body, it enriches the mind and stimulates the spirit.

Before going on to the slides, I would point out that there is a great difference between Mountain photography and mountaineering photography. In the former heavy apparatus and plates can be used, along with a tripod, and time taken in composing a picture on the focussing screen. On the other hand, small and light cameras, that can be easily and quickly brought into use must be used, since one must grasp opportunities that do not recur.

My slides were made, with one exception, from my own negatives, by Mr Ritchie. Though he has had some inferior material to work upon, in the shape of over and under-exposed negatives, he has, nevertheless, corrected many of their faults in the dark room. Those who know the great amount of labour and attention the making of slides entail, will realise how much credit is due to Mr Ritchie, and I desire to thank him, not only for preparing the whole of the slides, but also for his unfailing courtesy in helping me to choose the best negatives.

THE CUILLIN.

For the rock climber the Cuillin are the most popular hills in Britain. They are popular because they contain the finest rocks, the shapeliest peaks, the roughest corries, and the finest climbing. The ideal of the sport is to be found amongst them in its perfection. The climbing is mostly safe, because the rocks are sound. The views are superb, both near and distant. A constant feast of colour and of striking scenery is before the climber's eyes, and the shining plain of the sea spread out below ever turns the thoughts to Celtic mythology, to the Celtic paradise of Tir nan Og, the land beneath the waves.

At first the Cuillin, by their very bleakness and bareness, may appear revolting. A maze of shattered summits, blue-black or purple in colour, interspersed with high bealachs, which rarely fall much below three thousand feet, rise above lonely corries where silence reigns. Chaos of rock, wilderness of stone, such are the Black Cuillin of Skye. A few hardy plants cling to the outskirts of the range, but within that outer ring desolation is complete and wild life nil. However interesting these mountains may be to the geologist, they are useless to the botanist or zoologist.

Those of us who have seen the Cuillin from the deck of the little steamer off Mallaig across the tumbling wastes of seas, or have lain lazily all day on the sand beaches at Arisaig Point, looking to Skye and Rhum lying light-blue on the horizon, or have seen their jagged saw-edge across the moors from Talisker in the twilight, or have lingered at Loch Coruisk till the last ray of light has faded out behind Sgurr Alasdair—those of us who have seen the Cuillin thus will know that they are beautiful.

The rock-climbs are without end, yet of endless variety. The Pinnacle Ridge of Sgurr nan Gillean, the traverse of the Bhasteair Group, the Cioch and Inaccessible Pinnacles, the crossing of Clach Ghlas and Blaven—to mention but a few—are sound but exhilarating expeditions. But although the steep rock walls invite inspection, the true charm lies in the narrow and elevated ridges that yearly call us to the island with an appeal that cannot be denied.

The Cuillins are interesting from a geological point of view.

Succeeding a long quiet period, volcanic activity set in on a gigantic scale on the West.

From great vents on what is now the mainland, basaltic lavas welled up and spread across Skye, reaching as far out as St. Kilda. These successive sheets were laid down and had cooled when from beneath them, from pipes buried far underground, igneous matter was injected. This raised the basaltic sheets in the form of a vast dome, but failed to break through to the surface. This material solidified into the gabbro of the Cuillins. At a later date, a similar eruption took place beneath the basaltic sheets, and acid rock, in the shape of granite or granophyre, was erupted; this, too, failed to break through the basaltic sheets.

We must now imagine these sheets in the form of a vast dome, with an inner core of gabbro and granite. What colossal force was required to raise them we can only guess.

Subsequently the basalt was eroded entirely from the dome, and left the Cuillin and the Red Hills in Skye as we now know them. This explains the contrast between the smooth ice-ground corries and the shattered summits, for the peaks stood out above the ice, and suffered from erosion by frost and other natural agencies.

The south-moving glacier spread down Glen Sligichan to Camasunary, reaching almost to the level of Blaven, and part of it flowed over the Druim non ramh Ridge to LochCoruisk, the bed of which it eroded and formed.

THE CAIRNGORMS.

When one leaves the jagged ridges of Skye for the Cairngorms, the contrast is at once striking and apparent. Great plateaux and smooth tablelands are encountered, with precipices of red rock falling high into corries. There is not much bare rock in the region. The surface is everywhere in an advanced stage of disintegration. Cliffs have been tumbled into screes, and these in turn have been mantled with lichen and moss or with grass and heather, while on the higher plateaux and ridges are stretches of broken rock and gravel. At a distance they present rather featureless masses, with flat summits and rounded slopes.

This impression is largely modified as one enters amongst them, and especially when one comes in view of the noble range of corries which line their eastern and northern faces. These corries are particularly rich in lochs, which add largely to their interest and gradeur; not less wild than the cliffs are these wild lochs with their feeling of utter remoteness.

On the great wastes of shattered stone which form the summits of these mountains, only a few of the hardiest plants find a footing. Here are the largest areas of lofty ground in Scotland, where the forces of nature, frost and heat, snow and rain, wind and tempest, work with a power and force undreamed of at lower heights.

The very bareness of these mountain tops is on a majestic scale, and it forms one of the elements of massive grandeur and repose that are among the distinguishing features of the Cairngorms.

The first fleeting impression of these mountains may be one of disappointment, for their appeal is not of the picturesque or obvious kind, but as one wanders among them and explores them the magnitude of everything begins to reveal itself, and one realises the immensity of the scale in which the scene is set, and the greatness and dignity and calm of the Cairngorms cast their spell over the spirit.

Larig Ghru.

The granite of the Cairngorms has resisted the agents of denudation more successfully than the surrounding schists, and has established a radial drainage system. It is traversed by an old consequent valley with a high wind gap leading by the Lairig Ghru to the head waters of the Dee.

The Lairig Ghru is the best known feature of the Cairngorms. It is, I think, the finest hill pass in Scotland. Though annually numbers of tourists essay its passage, the crossing of the Pass is no mean feat, and minor accidents on the part of unprepared walkers are very numerous.

As the charm of the Cuillin is inseparable from the sea, so is the charm of the Cairngorms inseparable from the great pine forests of Rothiemurchus and Glenmore. Were it not for these magnificent woodlands, the northern foothills would be as bleak as the windswept Drumochter Hills.

The forest stands as a foil to the unalloyed barrenness of the mountains. It must be remembered that these are no ordinary forests. They are remnants of the ancient Caledonian forest that once covered the country, and each tree stands self-sown to this day.

The Eanaich Road.

Of all the paths in the Cairngorms, undoubtedly the Eanaich Road is the finest. It embodies in its 10 miles of length every variety of scenery, from the most luxuriant to the most barren, from the most peaceful to the most disturbing, from the most homely to the most weird. It leads from the valley to the hills, and while part of it is gay with flowers and rich in perfumes one may go forth from its other end to meet snowflakes upon the High Cairngorms. At the upper end of the glen lies Loch Eanaich, under the dark cliffs of Sgoran Dubh, the five great buttresses of which provide some of the best rock-climbing in the district. There are few more stirring scenes in this country than Loch Eanaich seen from the rock walls of Sgoran Dubh.

Loch A'an.

Loch Coruisk is usually accepted as Britain's wildest loch, but, although it is weird with the strange mountains around it, Loch A'an in the Cairngorms is undoubtedly more lonely. Perhaps it is the knowledge that one is remote from human habitation that increases the sensation, for the head of Loch A'an is indeed remote, and Glenmore Lodge, the nearest house, is four hours' away over Cairngorm. One climbs up from the head of the loch by the cascade of Garbh Uisge. The stream, with banks of bare gravel, is made if anything more desolate by cushions of black moss, which are almost the solitary sign of plant life among these wastes of sand and melting snow. Here, in this shallow basin on the north-eastern slopes of Ben Macdhui, the snow scarcely ever disappears. The surrounding slopes shut out the distant view in ever direction save by the way one has come. There are wilder and more rugged scenes in the Black Cuillin of Skye, there are loftier cliffs and precipices in the Allt a' Mhuillin Corrie of Ben Nevis, but nowhere else in this country is there mountain scenery of such grandeur, or scale, as that in which it presents itself to the climber during the ascent from Loch A'an to the summit of Ben Macdhui.

Glencoe.

The porphyry rocks of Glencoe offer a tempting array for the climber, and perhaps the ascents there approach most nearly to climbing conditions abroad, as the rocks are in places loose and friable, and care is necessary on the lower slopes.

Perhaps it is partly on account of its position that Buchaille Etive is so famous, as it towers grandly above Rannoch, and dominates Glencoe. It is one of the most shapely peaks in the West, and its two thousand feet cone of porphyry on its pedestal of heather is at once a challenge and a delight from Kingshouse Hotel. High on its upper rocks is the famous Crowberry Ridge, possibly the most delightful climb in Scotland, with its airiest of outlooks across Rannoch Moor. Buchaille Etive's neighbour, Bidean Nam Bian, the highest peak in Argyll, commands, from its central position, one of the farthest-reaching mountain views in Scotland, and in clear weather the coast of Ireland is visible. Just below the main peak is the notorious Church Door Buttress, its vertical crags but lately "unlocked for the faithful." Forming the north wall of the Glen, the schistose cliffs of Oonach Eagach rise steeply. Its narrow and pinnacled summit ridge provides a splendid excursion.

By a curious anomaly, Glencoe is at its gloomiest on a bright sunny day, which casts the shadows of the peaks across the deep gut of the pass. It is one of our finest outgates to the western sea.

Ben Nevis.

The usual impression of Ben Nevis is disappointing, and one hears it described as a shapeless, uninteresting mound, which, but for its altitude, has few attractive features. Yet, save in the wild recesses of the Cuillin, Ben Nevis has no rival in the British Isles for the savage grandeur of its rock scenery.

Of all the tourists who annually make its ascent, only the few, the very few, turn aside into the valley of the Mhuillin, or breast the slopes of Carn Mor Dearg. From there is revealed a scene of mountain grandeur. From either point of view, but altering in contour with every step, a range of stupendous precipies exposes a frontage of about two miles, and bewilders the eye with corrie and gully and shattered cliff. No mere dull featureless wall of rock uplifts itself, but rather a fascinating luring succession of steep aretes and ridges, pinnacles and gullies, affording a variety to suit the powers of all classes of climbers.

The mountain itself may be said to be composed of two layers, a lower layer of granite and an upper of andesitic lavas. Carn Dearg, on the other hand, is composed of a pink granite, resembling closely the Cairngorm granite.

The north-east cliffs are composed of lavas and agglomerates, tough rocks that are admirably suited for climbing. The Tower and Castle Ridges and the imposing North-East Buttress yield exhilarating climbs in summer conditions. In winter, the rocks in their iced condition are impracticable, and recourse is had to the numerous gully climbs.

Perthshire.

As far as rock-climbing possibilities are concerned, Perthshire is disappointing. But it is ideal for hill-walking, and one cannot go far wrong on the Ben y Ghlos or the Ben More groups at Crianlarich. But I would mention Cruach Ardrain and Ben Lui as two of our finest hills.

Perthshire is at its best under snow, and excellent days may be had with an ice-axe on the iron-hard névé of its winter slopes.

With regard to ski-ing, our own county offers most scope, and many fine days are to be had on the Drumochter Hills. The idea of an hotel for winter sports, however, is largely a journalist's dream, for good ski-ing depends on the condition of the snow, and while a great many good days may be obtained in a winter, they are usually detached from one another by periods of bad weather.

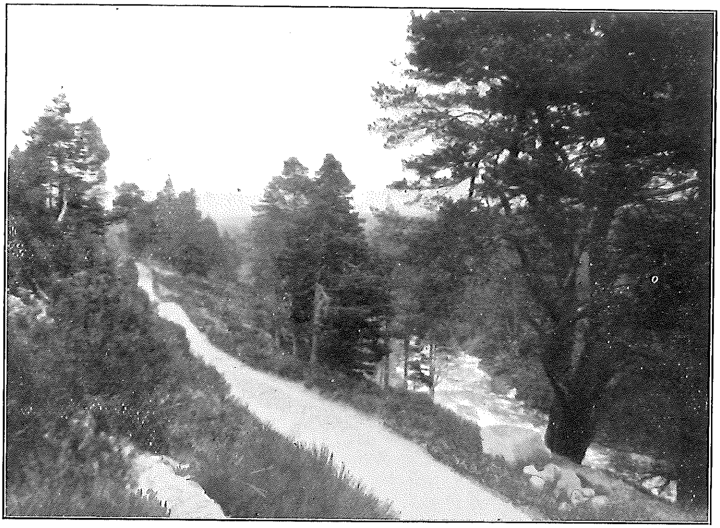
The gods, they say, sell everything at a price. In the hills are beauty, happiness, and things of the spirit, and if these are bought only at the price of incessant toil, frequent wettings, and still more frequent sweatings, we cannot grumble at the price.

III.—*Place Names of the Forth and Tay Area.*

By Arthur J. Brock, M.D.

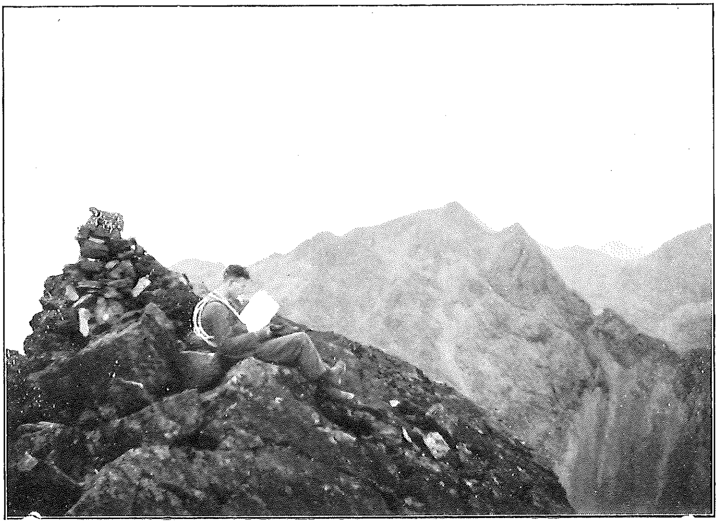
(Read February 14, 1930).

In the present mechanical age there is a predilection abroad, especially marked perhaps among "the powers that be", to rob not only persons but places of their individuality—or, at best, to slump as many of these as possible together into categories, or "grades."



The Eanaich Road, Rothiemurchus, near Caiggean Beannaidh.
PLATE V.

Ben Lawers, in March. From the north ridge of Ben Ghlas.
PLATE VI.



The Cuillin, Skye. Looking north-west from Sgumain to Dearg. The Bealach Coire Lagain is on the right, leading to Loch Coruisk.

PLATE VII.

Cairngorms. Looking south from Braeriach to Cairn Toul, across the Garbh Choire Mhor. The Larig Ghru on the left.

PLATE VIII.

A useful corrective of this dangerous tendency is exemplified in the various movements towards what has been called "Regional Survey." Many enlightened individuals are now realising that the best way of getting to know the world, and so to become educated and efficient, is to begin with that part of the world in which one lives, that part with which one is in immediate contact.

There are many different ways of approaching the study of one's own district, and, among those, one which I personally hold high in honour is that which I propose to bring before your attention to-night—namely, the study of local place-names.

I shall confine myself mainly to the region of the Tay and Forth, since in this district, apart from the fact that it is, so to speak, "at our doors," may be found practically all the elements that go to constitute the "toponomy" of most other districts of Scotland. *Ex uno disce omnes.*

To the study of our Scottish place-names there are again many different avenues of approach. Thus (1) we may examine names on the map. Map-makers' names, however, particularly where small places are concerned, often leave much to be desired; Gaelic names especially are often transcribed wrong. (2) We may examine documents, such as old abbey and other charters, kirk-session records, and the like. (3) We may consider the traditional local pronunciation; this is often of very great value, and should in every case be compared with the official name as written. Let us take two local instances of the guidance this method can afford. The hill, farm, quarry, etc., at North Queensferry, which for generations has been written Carlingnose, is still locally called by the older people, Carlin Knowes, showing that the name was originally taken from the "knowes" or knolls here, and has no reference to a nose or "ness" at all, as has generally been assumed: in other words, it is not a seaman's but a landsman's term. Again the old pronunciation of Kinghorn, still to be heard, is Kin-gorn, showing at least that the name has nothing to do with any "king", whether the ill-fated Alexander or any other; further on we shall see that this also is a landsman's and not a seaman's term, and the poetic interpretation "Blue Headland," so often given to it, does not apply. (4) But if we wish to study our Celtic place-names according to the methods of modern science, we must also, perforce, make ourselves acquainted with the work of Dr. W. J. Watson, Professor of the Celtic Languages and Literature at Edinburgh University. The appearance in 1926 of his book "The History of the Celtic Place-names of Scotland" was a landmark in the study at least of Celtic toponymy. Previous to this we had had for over a generation the "Place-names of Scotland" by Rev. J. B. Johnston of Falkirk, a valuable enough book, but one which suffers from the fact that its author, unlike Prof. Watson, had not been a Gaelic speaker from childhood; a particularly valuable feature of Mr Johnston's work is its inclusion of many old spellings from the *Origines Parochiales*; used critically and with discretion, this book is still the best general work on Scottish place-names that we possess; Prof. Watson's volume, however, stands in another category, and he would be a bold man who would lightly question its author's conclusions where at least Celtic roots are concerned.

Many of the more intelligent guide-books also give a certain amount of information on the meaning of place-names in their own localities, thus special reference may be made to a work such as "Kirkcaldy, Burgh and Schyre," which contains an authoritative chapter of "Old Place-Names" by Mr Lachlan Macbean of the "Fifeshire Advertiser," himself, like Prof. Watson, a native Gaelic speaker.

Ethnological Aspects.

From an ethnological aspect the words which go to make up our place-names can be thought of as deriving from two main sources, Celtic and Germanic; these again break up into other groups, the Celtic into Cymric and Gaelic, and the Germanic into Anglo-Saxon and Scandinavian. Cymric dialects are still spoken in Wales and Brittany, Gaelic in the Highlands, in Ireland, and in the Isle of Man. Scandinavian dialects are the vernaculars of Iceland, Norway, Denmark and Sweden, the Icelandic remaining nearer the form in which these languages were introduced into our islands in Viking times. In Caithness, Orkney, and especially Shetland, names of pure Scandinavian origin are common; in the Hebrides they have become peculiarly overlaid with Gaelic forms, although they are still obvious. The Scandinavian dialects play a very unimportant part in the topical nomenclature of the Forth and Tay; it is only north and west of the Moray Firth that they really require serious consideration. The various dialects of English and Scots can be looked on as in the main "Anglo-Saxon," and, of course, these form a very main element in our place-names, although much less in Scotland than in England.

The fact that these various languages take part in our local toponymy gives occasion for the use of the comparative method. Thus the same topographical idea is often found expressed in more than one; for example, we have pairs like Blackburn and Dou-glas, Bridge-end and Kinpont, Wood-end and Kin-cardine, and many more. An old Gaelic name in the Lowlands can often be understood best when compared with a term used where Gaelic is still spoken; thus Garvald in Lothian is obviously the same as Garbh-allt (Rough Burn), so common in the Highlands. Again an obscure term even in Gaelic-speaking areas may be quickly understood by comparison with a corresponding word in Ireland. Other Celtic lands and even sometimes non-Celtic lands may also be called in to help.

THE BRITISH, CYMRIC OR PICTISH GROUP OF NAMES.

It is convenient to begin with a consideration of words which are purely or predominatingly of Cymric or Brythonic origin. By these terms is meant all words which date from before the invasion of our country by the Gaelic-speaking Dalriadan Scots from Ireland. The people these invaders found here were—apart from the Northumbrians south of the Forth—in the main Celts, speaking Cymric or British dialects allied to the modern Welsh; the name Picts was generally given to these native inhabitants, and I shall use the terms Pictish, British, and Cymric here as interchangeable.

An old saying in the South-West of England distinguished the Cymric family-names of Cornwall as follows:—

"By Tre, Pol, and Pen
Ye shall know the Cornish men."

The same applies to the decipherment of our Cymric or Pictish place-names in Scotland, and if, for the sake of a mnemonic, a very crude extension of the above couplet is admissible, we might put it:—

"By Tre, Pol, Aber, Pit, and Pen
Our Pictish place-names ye shall ken."

ABER, a river-mouth, the Pictish equivalent for Gaelic *inver*, and later, as we shall see, often displaced by the latter. Aberdour, Aberfoyle, Abercorn, Aberbrothock (Arbroath), etc. In Cymric Wales we have, similarly, Aberystwyth, Abergavenny; in Brittany, Abervrach.

CAER, a camp, entrenched and stone-girt. Carmarthen, in Wales, means Merlin's *caer*. In Brittany there are many places called Ker. Keir, in Menteith, is but one of a chain of rude forts called "Keirs," which can be traced along the north edge of the valley or strath. With us the word usually becomes Car in place-names; thus Carnoustie, Carnethy, Carlowrie, Carriden; Cramond is the Caer of Almond. Kirkcaldy is not really a "kirk" but a "caer," and a better spelling would be Caercaldy. It has even been suggested to me that the Burn of "Care," above Dollar, may be named from a local caer—and that thence all the further romantic names in the district, like Burn of Sorrow, Castle "Dolour," and Gloom, may have taken their rise! This, however, is doubtful.

CARDEN is a Cymric word meaning a thicket or copse. The frequently recurring name Kincardine thus means nothing more than copse-end, wood-end; Carden-den, the dell or dene at the wood-end. Fettercairn used to be spelled Fetter-cardin.

LANN, an enclosure, particularly a sacred enclosure or church. Common in Wales and Brittany; thus Llanfairfechan means Little Mary's Church. Lanmeur, in Brittany, means Big Church, Lamballe the Church of St Paul, Langoat the Forest

Church. The word was common in Ireland, and in Scotland we have Lanbryde, the church of St Bride or Bridget. Lumphinnans, in Fife, may signify the church of St Finnan. Pencaitland seems to mean the head of the "coetlan" or forest enclosure; here Coetlan, the old spelling, is the same as the Breton Langoat mentioned above, with the syllables transposed.

LINN was an old name for a lake in Scotland; in modern Wales, llyn is the ordinary word for a lake. We get the word in Loch Linnhe (a pleonasm), and it seems to form the root of names like Linlithgow and Lindores, where lochs still exist; also of Lintrathen and Linlathen. Lindores may mean the Loch of the Gap or Gateway, there being here a notable gap or pass over the Ochils on the road from Perth to the Howe of Fife. We may ask if the word does not also form the last syllable of Dunfermline and of Rosslyn; at both these places we have an ancient castle built upon a steep peninsular rock, half encircled by a rapid stream; at Rosslyn the rapids below the castle are still called the Linns.

OCHIL.—This is the Welsh word *ychel*, meaning simply high, abrupt. It is especially applicable to the Ochil Hills, which, by virtue of a geological "fault," rise with peculiar abruptness from the plain. Ochiltree, or High Stead, is a farm standing high up on the north edge of the West Lothian uplands.

PEN, a head, end. This is the Cymric or British word which corresponds to Gaelic Ken or Kin (*ceann*), a head, and with which I shall deal later. Common in Wales (Penmaenmawr, the head of the great rock, etc.), this occurs in Scotland only south of the Forth. Penicuik means the head, top, or hill of the cuckoo. Pencaitland, as already mentioned, means the head of the forest enclosure (*coetlan*). We have Penpont in Dumfriesshire, meaning bridge-end; on the Borders we find hills like Penchrise, Pennygant, and the Pen of Ettrick.

PERTA, a wood, a copse. This seems to be the meaning of Perth, which in Gaelic is Peart. In Welsh, perth means a bush, brake, copse. Perthes is a common place-name in France. In Scotland we also have Logie Pert, Mill of Pert, etc. Larbert seems to be related.

POL, a slow-running stream, a "pool." In Wales we get Pont-y-pool and Pwllheli, the latter with a nearly landlocked natural harbour, which is probably the "pwll" meant. In our own district occur names like Polmont, Polkemmet, Polmaise. In the Scottish dialects Pol becomes Pow; thus a Pow-burn is a slow-running burn. The word has also been taken into Gaelic; Aberfoyle is Abar (or Obar) a' Phuill, meaning the mouth of the pow-burn. Pouldu, in Britanny, means the Black-pool. Compare Blackpool, Lancs.; also Dublin, which is Dubh-linn, likewise meaning a black pool.

PREN, a tree. Pirn and Pirntaiton. Barnbougle, near Dalmeny, was originally Pren-bugail, the herdsman's tree.

TRE or TREF, a stead, a "toun." In Wales this is a word for a farm-stead, corresponding to Baile in Scotland and Ireland (of which later). Thus in Wales we have Trefnant, answering exactly to our Tranent, meaning the stead in the valley or dingle. Ochiltree, already mentioned, means High Stead. Compare Cornish Trelawney, Breton Tréguier, etc. The same word occurs in Traprain and Trabroun, and probably in Rattray and Niddry (the latter meaning New Stead).

BRITISH-GAELIC NAMES.

In the middle of the ninth century, it will be remembered, Kenneth Macalpine, King of the Scots, conquered the Picts, and became head of a combined Scoto-Pictish nation. The two languages now gradually blended, or rather the Pictish became absorbed into the Gaelic. A number of our place-names date apparently from a time when this process of blending was still incomplete, and we find several words which are half-Pictish half-Gaelic. Thus we have the modern Kinneil, on the Forth, written Penfahel, meaning the head or end of the wall (vallum). Kirkintilloch was originally Caer-pen-taloch, the fort at the head of the hillock.

MONADH.—This is a Gaelic word which has been brought over from the British. It means an upland, a muir, a range, and in modern Welsh is *mynydd*. "The Mounth" was an old name for the Grampians, and in part of this range it still exists as "Mount"—*e.g.*, Mount Keen (beautiful mountain; Gael. Mon' Caoin). Mona(dh) Lia, in Badenoch, means grey mountain, grey range; Moncrieff means hill of the tree or trees. Commonly the word remains as a last syllable, as in Polmont, Glassmount, Dechmount, Stormonth; in these cases it means often an upland or muir, rather than a range or hill.

PIT or PET, a stead or toun, like TRE. A very characteristic British or Pictish word, but one which, in combination at least, has often become more or less Gaelicised. The Pits are found mostly north of the Forth, and on the east side of the country. The word seems to have been specialised in Pictland, as we do not find it in Welsh or Breton place-names. Pitreavie, Pitscottie, Pitliver; Pettycur is a Pit, and does not come from French *petit*, as often stated. Pendreich was originally Pittendreich. Bantaskin, near Falkirk, was Pettantaskin. Pit or Pet in modern Gaelic has often become replaced by its equivalent Baile, but, strangely enough, sometimes survives in the English form of the name; thus, Pitlochry in Gaelic is Baile Cloichrich (Stoney Stead); Pitcastle, near it, is Baile a' Chaisteil; Pitmain, at Kingussie, is Baile Meadhoin (Middle

Toun or Stead). Pittencrieff corresponds exactly to the more frequently recurring Ballencrieff (Tree Stead).

PONT, a bridge. Common in Welsh and Breton; thus Pontypridd, Pontypool, Pontaven. In Penpont, Dumfriesshire (Bridge-head), we have two British words existing unchanged; but in Kinpont, West Lothian (nowadays written Kilpunt), we find the Pen replaced by its Gaelic equivalent Kin (*ceann*).

A WORD ON PRONUNCIATION.

Before we come to the purely Gaelic names, one or two notes as regards pronunciation may be conveniently made. In Scottish place-names the letter *l*, although written, is often not pronounced. Thus Poll or Pool becomes Pow; Dalyell becomes Da'yell; Ballingry, Bingry; Dalgetty, Daggety; Culross, Cooross; Dallachy, Daichy; Balhousie, Boozie; Tulloch, near Stirling, becomes Touch; Dumanie, the old spelling of Dalmeny, suggests that the *l* was at one time elided in speech. Kirkcaldy is pronounced Kircoddy or -caddy.

In Gaelic the letter *t* becomes often "aspirated"—that is to say, it tends to sound as *h*. This tendency has been continued, even where Gaelic is no longer spoken; thus, Strathmiglo is pronounced locally Strah'migly; Strathaven becomes Straven, etc. Even the Glasgow vulgarism wa'her for water may thus claim perhaps a Celtic sanction!

Another Gaelic tendency is for the letter *f* to be aspirated; it then ceases to be sounded altogether. Thus, Aberargie is really Aber-Fhargie, the mouth of the Farg. Anacroich, in Kinross-shire, as proved by old documents, is Ath-na-fhraoich, Heather-Ford.

Another interesting development in the direction of softening or "refining" harsh sounds is illustrated in the change of some non-Gaelic words. Thus, the common term Haugh (low-lying land beside a river) becomes first Ha', and is then further transposed into Hall. Beside the Haughs of Airth farm in Stirlingshire we find a modern "Halls of Airth" chicken-farm or market-garden. Tod's Haugh at Kirkliston has long since been transmogrified into Foxhall (Fox being actually a translation of Tod). Haugh itself becomes sometimes confused with Heugh, a cliff, as at Ravenshaugh, near Musselburgh. Hall, too, may be corrupted; thus, the so-called Hawkcraig at Aberdour, in Fife, should be Ha' Craig.

"PURELY" GAELIC TERMS.

I shall now mention some of the commonest purely Gaelic root-words which occur in our place-names. A few Saxon terms will also be included, mainly for comparative purposes.

ALLT, a hill-burn. Common throughout the Highlands. In the south, Garvald, Rough Burn, occurs more than once. Auld Cathie, in West Lothian, means probably the Battle Burn (allt catha). The genitive of allt is uillt, which gives us Taynuilt (taigh an uillt), Burn-house, Burness, Burns; hence the name of Robert Burns, whose family are said to have come originally from Taynuilt district to Kincardineshire.

AVON (abhainn), a river. This is an ordinary Gaelic word, but, according to Prof. Watson, neither of the rivers Almond or Avon, either in Perthshire or Lothian, come from this directly, although related.

BALLO, a pass (bealach). A pass over between the two Fifeshire Lomonds is so called; compare Balloch. English or "Saxon" names for the same thing are—hause, slap, slack, etc. The Cauld Stane Slap leads over the Pentlands from West Lothian into Tweeddale. The Paddy Slacks is a pass between Tweed and Ettrick. Possibly the Hawes Brae near South Queensferry may have been originally a hause leading down to the water's edge; or, again, the name may apply to the narrow sea-strait at Queensferry, as it does in the Swedish Hälsingör (Elsinore) and Hälsingborg on the Sound; also Hälsingland; all these are connected with hals, Scot. hause, a neck or throat, and so a "strait gait." The Hawes Inn is officially at New "Halls" (*cf.* Haugh, etc., above). A little farther east on the Edinburgh road, is a place locally called Corsaws, where there is an old cross, and which perhaps means "the Cross Hause." Another "pass" name is swyre: the Rede Swyre, Manor Swyre.

BEN, the commonest Gaelic term for Mountain. Scotland is referred to in Highland toasts as "Tir nam Beann," the Land of Mountains *par excellence*. Coming south, we find the word changing a bit; thus, there is the Binn of Burntisland, the Muckle Binn in the Campsie Fells, Binnie Craig in West Lothian.

BLAIR, a field. Blairgowrie, Blair Atholl, Blairingone (Field of Hounds). The Blair of Atholl contrasts with the "Braes" of Atholl.

BOTTLE (Saxon), a dwelling. Newbattle, Morebattle, Elbottle (E. Lothian), Harbottle (Northumberland), Bootle (Liverpool), Wolfenbüttel (Germany).

CAMUS, a bend, crook, bay. Cambus, Cambusmore, Cambuslang are all on big river-bends. A corresponding Saxon term is Crook; *e.g.*, Crook of Devon, Caldercruix (where there are many big bends or crooks on the river Calder).

CNOC, a hill. The Knock Hill of Crieff, of Saline, etc. Knox is a plural form, like Caldercruix.

COMRIE, a confluence. There are several of these. Cumbernauld is probably Comar nan allt, Confluence of Burns. Cummertrees contains the same root. In Brittany it is Kemper (Quimper).

CONEY-GARTH, a rabbit-warren. This is an interesting Saxon term, occurring as the Cuninghar at Tillycoultry, the Cunnigar at Midcalder, and the Cunyngarland at Burntisland, where of old the monks of Dunfermline possessed rabbit-warrens. The Kinniker is part of the minister's glebe at Torphichen in West Lothian.

CRAOBH, a tree. Crieff, Pittencrieff, Ballencrieff, Moncrieff Hill.

ECCLES, a church. One of many Latin words brought into Gaeldom by the early Latin-speaking missionaries. Eaglais is the ordinary modern word for church. Corrupted, it gives us Legsmalee, near Kinghorn, "Church of St Mallie" (*cf.* Dalmally, Kilmallie, etc.); also Exmagirdle, an old chapel near Dunbarney in Perthshire, meaning "Church of My Grill," that is, of St Grill. Glen Eagles does not seem to mean Kirk Glen, as the *l* is absent in old spellings.

DUN, a fort. Extremely common. Dundee, Dunfermline, Dunedin (Edinburgh), Dunkeld, Dunbar. The -dee of Dundee is, according to Prof. Watson, a man's name (unnecessary to state, the "Dei donum" theory is pure punning). As already mentioned, the -lin or -line of Dunfermline may refer to the "linns" in the river below, as at Rosslyn. Dunedin is certainly not "Edwin's Burgh"; nor has the -edin part to do with Gaelic aodann, a face, a rock-face, as has Edinample. Doune was of old "the Dun of Menteith." Other Celtic names for forts are caer (already discussed) and rath (Ratho, Raith).

DRUIM. The ordinary Gaelic for a Back or Ridge, corresponding to Scotch Rigg or Riggin. It has also been taken partly over into Scotch in the form of Drum Brae, of which there are many instances. Drumbeg means the Little Ridge, Drumbowie the Yellow Ridge, etc. The Drumouchter Pass, between Atholl and Badenoch, is Druim-uachdar, "Upper Ridge." Drymen is a locative form of Druim. The so-called Riggin of Fife, bounding the Howe of Fife on the south, would no doubt be called the Druim in Gaelic. Drum becomes sometimes confused with Dun in place-names.

ERN, a rather interesting Saxon name meaning a dwelling. Dreghorn is Dreg-ern, the Dry Dwelling; Whithorn, Whitern, the White House (Candida Casa). *Cf.* Herne Bay, and the Chilt-ern Hills.

GASK (Gael gasg), a tail. Not uncommon for "a tail-like point of land running out from a plateau" (Prof. Watson). Magus Moor is Magh-gasg, the Tail of the Plain.

INVER.—As already said, Inver is the Gaelic term which has in great part dispossessed the older British term Aber, much as Kin has displaced Pen. Inverkeithing, Inverleith, Inveresk. It is noteworthy that both the latter names are now applied to places somewhat higher up the river than the actual mouth. Leith is a shortened form of Inverleith, the mouth of the Leith Water. The meaning of Leith itself is not clear.

INCH, an island, a holm. Inchkeith, Inchcolm, Cramond Inch, the Inches of Perth, Markinch (the Horse Holm, *cf.* Penmarc'h in Brittany, meaning Horse Point), Inchdairnie, the Inch, near Edinburgh. These names often point to a time when the place was surrounded by water, although now dry. Priestinch, near Winchburgh, is where was the former Duntarvie Myre.

KIN, a head, headland. Cinn is really locative of ceann. People of old, as primitive and "natural" people nowadays, did not think or speak of a place in an abstract way; they said that a person was "at" or "in" a place, etc., they thought of places and people together; hence many of these old place-names have come down to us in *locative* forms. Kinloch means "at the head of the loch," not simply Loch-head; Kinross, at the head or end of the peninsula; Kincraig, at the Craig-head; Kingorn, at the marsh-head; Kin-glassie, at the burn-head; Drymen, on the ridge. Similarly, the not uncommon Saxon name Letham means At or on the Leiths (slopes).

KIRKTON.—Anciently there used to be little separate communities grouped round the kirk, the castle, the mill, etc. Hence we find the Kirkton, the Castleton, the Milton, etc. Kirkliston was originally simply the kirk-town of Liston; there were also Old and New Liston, Liston Shiels, etc.; at Yetholm on the Borders we have Kirk Yetholm and Town Yetholm, definitely separate. Gaelic Clachan is one equivalent for Kirk-town; thus we have the Clachan of Campsie, where the old church is; the Clachan at Aberfoyle.

LARG, a slope. Largs has the English plural ending.

LOMON, a beacon. The Lomonds of Fife, also Ben Lomond, are simply "beacon" hills, like Welsh Plynlymon; Lat. lumen, light; Scot. leme, a blaze. In ancient days warning signals were lit on such isolated peaks; compare also Tinto in Clydesdale, from *teine*, fire, "Fire Hill."

RINN, a point, headland. Rhynd is the wedge-shaped piece of land between Earn and Tay, where they join; similarly a point caused by the winding of the Forth near Alloa is called Rhind.

SEAT.—This occurs both in English and Gaelic, the former being probably usually a translation of *suidhe*, a seat. Arthur Seat may have been looked on as the seat of the demi-god Arthur, as Cader Idris in Wales means the Chair of the giant Idris. Suidhe Fhearguis in Arran means Fergus' Seat. "Suie in Glen Dochart is locally connected with St. Fillan" (Prof. Watson), *cf.* the Suidhe in Bute. Sometimes the term referred to a resting-place at the top of a pass where funeral parties halted; *cf.* Gleann an t-Suidhe, Arran, and Bealach an t'Suidhe (Bellochantuy), Kintyre, meaning Glen and Pass of the Seat.

SHIEL, SHIELING, a temporary hutment, either on the hills for summer grazings, or at the river-sides for fishers. Blackshiels and Brothershiels in the Lammermoors; Liston Shiels in the

Pentlands. Galashiels and North and South Shields on the Northumberland Tyne were probably temporary encampments for fishers. The Gaelic for a mountain shieling is *airidh*; Fiunary, the White Shieling. *Skjul*, pronounced shiel, is the ordinary Swedish word for a shed.

SHORE, quayside. The Shore of Leith, Newburgh Shore, on Tay. Carronshore is the little port at the Carron mouth which preceded Grangemouth.

TOR, a hillock. Torduff and Torfinn, the Black and the White torrs. Torran is a diminutive: thus Torrance is really "the Torrans"; *cf.*, Knox, which means "the Cnocs."

TOUN, a stead. This is the commonest Saxon equivalent for Celtic terms like Tre, Tref, Pit, Bal. See Kirkton, Milton, etc., above. The simplest significance is a "farm-toun"; Gael., *baile*: thus Balmenach is "Middletoun." *Cf.* Pitmain, above.

TULACH, a hillock. Tulloch, Tullochgorum (Blue Hillock), Tillicoultry, Kirkintilloch (*v.* above). In the Touch Hills near Stirling we have Tulach with the letter *l* elided, as so often in other Scottish place-names.

UACHDAR, upper part, upland; also cream. Auchter-arder, -muchty, -tool, -derran. Drumouchter.

WEEM (Gael., *uaimh*), a cave. Weem at Aberfeldy. In Wemyss we have the English plural, as in Knox, Torrance, and Largs. Uaimh Mhor, the Big Cave Hill, in the Braes of Doune, has become corrupted to Uam Var. *Cf.*, the Cave Hill at Belfast.

VARIOUS.

OTHER ECCLESIASTICAL TERMS.—I have spoken of Eccles, one of the words brought in by the Latin-speaking early Christian missionaries, and adopted in Gaelic. Another very interesting church word is Baculum, a staff, a pastoral staff; this appears in the Lothian and Fife place-names Pitbauchlie and Barbachlaw, and really means land belonging to a bishop (whose symbol was the staff or crosier). On the island of Lismore in Argyll the Bachull Mor, or Great Pastoral Staff of St. Moluag was long cared for by the "Barons of Bachull."

Again, Latin Abthana, meaning Abbey Lands, gives us Abden at Kinghorn, Appin in Argyll, and the Abthane of Ratho in Midlothian (now Ratho Byres). *Cf.*, Appenzell in Switzerland, originally Abbatis Cella.

The Latin Cella itself supplies our innumerable Kills, dedicated to ancient Celtic saints; Prof. Watson's book goes into these in great detail.

The Saxon term GRANGE refers usually to the granges or barns of religious houses. Thus we have Newtongrange, belonging to the monks of Newbottle Abbey; Grange near Bo'ness was probably a farm or grange of Culross Abbey, on the opposite side of the Forth; the Grangepans, close by, were the salt-pans of this grange. The Prestonpans were the salt-pans of the Preston, or priest-town, pertaining to Newbottle Abbey.

The common farm-name Borland or Boreland means Board-land, land for supplying the board or table of some religious house.

Spittalfield means Hospitalfield, probably largely reserved in the Middle Ages for lepers.

Field-Names.—Under the old open-field or runrig system there were scattered patches or "shotts" of arable land, each of which was divided into strips or "rigs," separated from each other by unploughed "baulks." From the first of these terms comes Shotts in Lanarkshire; also names like Barn-shot, Burn-shot, etc. The terms rig and baulk are still common in the names of fields, although the old system of husbandry has disappeared. Other field-names are plats or flats (Faulding Flatts, Kirkliston). "Floors," often pronounced flairs, is another not uncommon field-name; this, and not French *fleurs*, is quite probably the origin of Floors Castle at Kelso; two separate fields at Kinglassie are called Flowers o' May. "Gauze," a farm near Bo'ness, means perhaps "gaws," or open drains.

Old measures of distance are indicated in Four-mile Hill, west of Edinburgh, and Three-mile Toun, east of Linlithgow; both of these refer to the old "lang Scots mile." The old term for a road was gait (Swedish, gata); the Kirkgait, Swedish, Kyrko-gata; "gang yer ain gait." Crossgates is at the cross-roads. Howgate is a "hollow road" or lane (French, chemin creux).

Former owners are recalled in Otterston (Othere's toun); Elphinston (Alpin's toun); Pumpherston (Pomfret's toun); less ancient are Philpstoun, Norman's Law, Charleston (named after Charles, Lord Elgin). Swanston, near Colinton, is perhaps the toun of the swain or hind; this farm was originally a grange of Whitekirk Abbey.

Other Languages Involved.—Although many of our Saxon or Scottish place-names closely resemble names in the Scandinavian tongues, we are not to think of the former as derived from the latter; both have merely a similar ancestry—like men and monkeys! Particularly in the Forth and Tay areas the old Norsemen have left very few direct traces in nomenclature. Even Ness, as in Fifeness, Bo'ness, is Saxon, not Norse.

On the other hand, there are a number of interesting French place-names, coming from mediæval and renaissance times. Thus the early religious houses have left names like Bowprie (beau pré, fair meadow), Pleasants (plaisance), and Jamphlars (champ de fleurs), in Fife. The Franco-Scottish Royal houses at Holyrood and Linlithgow give us Burdiehouse (Bordeaux House), and perhaps Champfleurie, and Champany (Champagne).

* * *

In concluding I would venture to hope that this fragmentary exposition may have interested some of you to whom the subject is relatively new, and that it may have even suggested possibilities towards a renewed appreciation of the *genius loci*. The *genius loci* is a spirit which our forefathers worshipped under many different names, but the rackety modern age threatens to deprive us altogether of a sense of its presence.

I would urge those of you who know no Gaelic to learn at least as many of the topographical terms in that language as possible; they are very easily acquired.

Finally, for those who are prepared to do some pioneering work in this department, I would suggest the collecting of local field-names. These names do not exist even on the large-scale Ordnance Survey maps, and their study undoubtedly opens out many new perspectives not only in philology but in the scientific understanding of our country's past history.

IV.—*Some Aspects of the Herring Family. Presidential Address.*

By William Malloch, B.Sc.

(Read March 14, 1930.)

It would appear customary for the President to address the Society upon some special subject to which he had devoted attention, or, alternatively, upon the work and activities of the Society during the session. To-night I purpose taking the former course. So long ago as 1895 the Society published a series of papers entitled "The Natural History of the Banks of the Tay." In the preface, the Editor lamented that the important section of the fishes had to be left out. I am not aware that many of the blanks have since been filled, and it will be my endeavour to lessen their numbers. The field is indubitably wide, and one is embarrassed by the suitability of choice for a brief address. Two years ago Mr. Menzies chose for his Presidential Address "The Potato." What could be found more suitable to accompany the homely tuber than the succulent herring. My remarks, therefore, will be devoted to some aspects of the herring species.

As many of you are aware, the sprat and the herring frequent the Estuary of the Tay, and therefore come within the scope of the Society's Regional Survey. A fortnight or so ago, I had brought to me a sample from a sprat boat's catch. The sample contained 450 so-called sprats, two immature angler fish, two shrimps, one sand eel, and one immature rock cod. Of the 450 so-called sprats, 325, or fully 70 per cent., consisted of immature herrings averaging rather less than five inches in length and 46 or thereby of which equalled one pound in weight. The remaining 125, or slightly under 30 per cent., consisted of sprats (*Clupea sprattus*) averaging four inches in length, and 53 of which equalled one pound in weight. The largest herring measured 5¾ inches from tip of snout to fork of tail and weighed just under one ounce. The smallest was 2¾ inches in length and weighed one-twelfth of an ounce. The largest sprat was 4¾ inches in length and weighed half an ounce. The smallest was 2⅓ inches in length and weighed one-sixteenth of an ounce.

Three days ago I had occasion to examine a box of whitebait in one of our fishmonger's shops. Each of the specimens examined belonged to the sprat species, the sizes varying from 1¾ to 2½ inches. Since there is a very close resemblance between the sprat and the immature herring it might reasonably be asked how one can differentiate between the two species.

"What is a Sprat?"

Sprat fishing has figured somewhat prominently in the daily press of late, and doubtless a few of the more curious readers may have had recourse to a dictionary. We find in Chambers's the following definition: "A fish of the family Clupeidae, like the herring but much smaller.—Sprat weather, the dark days of November and December." We gather, therefore, that the sprat belongs to the herring family, appears to be a distinct species, smaller than the common herring, and is associated with the months of November and December. The definition of Clupeiod is given thus: "A kind of herring (*L.*, *Clupea*, a kind of fish)." This does not afford much enlightenment. On referring to the word "herring" we find: "A common small sea-fish of great commercial value, found moving in great shoals or multitudes." The sprat, therefore, is gregarious and probably of commercial value.

Fifty odd years ago the authorities on fishes were divided on the relationship between the herring and the sprat. In the "Harvest of the Sea," published in 1865, James G. Bertram holds a strong view. On page 289 he states: "It is generally known that the sprat (*Clupea sprattus*) is a most abundant fish, so plentiful as to have been used at times for manure. The fact of its great abundance has induced a belief that it is not a distinct species of fish, but is, in reality, the young of the herring. It is true that many distinguishing marks are pointed out as belonging only to the sprat—such as its serrated belly, the relative position of the fins, etc. But there remains, on the other side, the very striking fact of the sprat rarely being found with either milt or roe. As to the serrated belly, we might look upon it as we do the tucks of a child's frock—viz., as a provision for growth.

"The slaughter of sprats which is annually carried on in our seas is, I suspect, as decided a killing of the goose for the sake of the golden eggs as the grilse-slaughter which is annually carried on in our salmon rivers."

I venture to suggest that Mr Bertram was as unsound on the sprat question as he was on the so-called grilse-slaughter.

The Sprat (*Clupea Sprattus*).

Distinguishing Characters.—Like all members of the herring family, the sprat has a single short dorsal fin placed near the centre of the back, and the edge of the belly is sharp, covered with a row of scales which have keels ending in sharp points. The scales are large, thin and deciduous. The general appearance is that of a squat fish deep in proportion to its length. The body is very silvery and iridescent and the back bluish and greenish. The head is proportionate to its size, the under lip slightly projecting giving a pug nose appearance to the fish. There are no radiating lines on the gill covers. On removing the gill covers a sieve-like apparatus known as gill rakers may be seen. By means of these gill rakers the Clupeiods strain from the water the crustacea and free swimming creatures on which they feed.

The chief differences between the sprat and the immature herring may be summarised as follows:—

1. The serrations on the belly are much stronger and sharper in the sprat than in the herring. In the latter fish the spines are almost imperceptible between the ventrals and the head.
2. The position of the dorsal fin in relation to the ventrals differs considerably. In the sprat the dorsal fin is slightly behind the ventral and in the herring it is slightly in front.
3. The hinder edge of the upper jaw of the sprat is in line with the front edge of the eye; in the herring it is in line with the middle of the eye.
4. There are no teeth on jaws, tongue or roof of mouth of the sprat. In the herring there are small easily detached teeth.
5. The sprat has forty-seven to forty-eight vertebrae whilst the herring has from fifty-five to fifty-eight.
6. The head of the herring is slightly larger than that of a sprat of the same size and not so pug shaped, the upper lip generally protruding to a greater extent.
7. The body of the sprat is squat, that of the herring more elongate. If a line be drawn from the centre of the eye to the fork of the tail the bulk of the sprat is seen to be below this line. In the herring the line appears to divide the fish into two equal parts.
8. The scales of the sprat are larger and fall off more readily.

9. The rays of the caudal fin or tail of the sprat are more strongly marked than those of the herring and usually present a ragged appearance.

HABITS.—The sprat frequents the estuaries and mouths of rivers, being found in large numbers between Newburgh and Tayport. In the spring the mature sprats begin to leave the estuary and spawn in the deep water off the coast. The egg is pelagic or buoyant, and may be recognised by the division of the yolk into separate angular portions. It is very transparent and the space within the egg membrane is small. The egg develops and hatches in three or four days. The larva when newly hatched measures from .12 to .15 of an inch, and is very transparent, with only a few minute black specks on the body. From two to three months onwards after hatching, the sprats make their way coastwards and are caught as whitebait measuring from one inch upwards. They remain in the estuaries, river mouths and bays until mature, a process which takes two or more years. The spawning period extends from March to June, but the adult sprats do not appear to return immediately to brackish waters. The principal sprat fishing on the Tay is from October to January. During the months of October, November, December the catches from the sprat yawls in the Firth of Tay show a slight preponderance of sprats. From January onwards the percentage of immature herrings increases from seventy to eighty and upwards.

METHOD OF CAPTURE.—Sprats are caught in the Tay Estuary principally by means of "boom nets." The sprat yawl is anchored in the river and the boom-net is lowered to the bottom. The net resembles a long poke or funnel, wide at the mouth and tapering to a few inches in diameter at the end or tail. The mouth of the net, which measures 25 feet wide by 20 feet deep, is kept open by means of two long wooden beams, or booms, placed at the top and bottom of the net. The netting usually consists of three portions, the front being composed of one-inch mesh and the tail or end portion of very fine mesh. In England this form of net is known as a "stow-net." The net is set facing the flow or ebb of the tide and few if any fish, whether salmon or sprats, can escape, once they have found their way into the inner part of the net. When a yawl is fortunate enough to strike a large shoal the net becomes filled in a few minutes and a few hours may elapse before the catch is finally secured and stowed in the hold.

MARKET.—The sprats, usually sold by the cran, are disposed of at the docks at Dundee. The buyers consist of fishmongers, canneries and farmers. The latter use the fish as manure. A few boxes are bought as bait for salmon fishing and the old adage: "A sprat to catch a mackerel," should now read: "A sprat to catch a salmon." Whitebait are considered a titbit in various localities, but there is no regular whitebait fishing in the Tay Estuary.

SIZE.—The sprat never attains to a large size; the largest may reach six inches in length. The sprat is known in parts of Scotland as the garvie, garvock or garvie-herring.

THE HERRING (*Clupea harengus*).

PRINCIPAL CHARACTERS.—The ventral fins behind the commencement of the single dorsal, which commences midway between the tip of the snout and the base of the tail. There are no radiating lines on the gill-cover. Small easily detached teeth on the jaws, on the roof of the mouth, and the tongue. The hinder end of the upper jaw is beneath the middle of the eye. The colour of the back is darker than that of the sprat. The spines or serrations on the belly are weak and the edge rather blunt. There are fifty-six vertebrae in the spine. The head in immature fish appears too large for the body and the under lip projects beyond the upper lip. The scales are of moderate size, thin and deciduous.

HABITS.—There are two types of this particular family of herrings, the winter and the summer herring. Since the winter herring is the type met with in the Tay Estuary, the description will be confined to it. The theory of migration of the herring from west to east and from north to south has long been abandoned, and it is now accepted that the herring remains within the areas in which it has been reared.

The winter herring spawns during the winter months in the shoals, rocks, and seaweed of our estuaries. The eggs are adhesive and heavy, sticking firmly to rocks and seaweed. They are not very transparent and the yolk masses are formed of globules of various sizes. The space within the egg membrane is greater than that found in buoyant eggs. The embryo in the developing egg is long, so that the head and tail almost meet round the yolk. Hatching takes place in from three to four weeks and the larva is over .20 of an inch in length and more fully developed than in the case of the sprat. The eyes are black and the mouth is open. After two or three months the scales begin to develop and the silvery skin is formed. At this stage the larvae are from one to two inches in length. They may remain in the brackish water for the first year of life and then proceed to the bays round the Fife and Angus coasts. The adult stage is reached after two or more years of life.

METHOD OF CAPTURE.—Apart from the form of fishing in the Estuary known as boom or stow nets, the methods of seine netting and drifting are chiefly used for the capture of herring. The seine net or ring net consists of a long net provided with corks or floats on the top rope and weighted at the bottom to keep the net in a perpendicular position in the water. The net is paid out so as to encircle the shoal and is then drawn either on shore or on board. This is the method used in Loch Fyne and recently introduced on the Fife coast by the Loch Fyne men. It is claimed by the Fife drift fishermen that this method is deadly and destructive of immature fish. The drift net, on the other hand, consists of a long net, or a fleet of long nets, shot in a long line and allowed to drift in the direction of the tide. The fish are caught by becoming enmeshed in the netting and hung by the gills. Small and immature fish pass through the meshes without scaith.

USES.—Everyone is familiar with the herring whether fresh, kippered, salted, cured or canned. It is largely used as bait for cod, ling and long line fishing generally, and when plentiful is frequently sold for manure. The largest herring found off our coasts do not exceed twelve inches in length and about half a pound in weight. In Norway, however, much larger specimens are found, and some Norwegian herring on the slab of a Perthshire shop the other day weighed fully three-quarters of a pound. The herring industry gives employment to many, fishermen, fisher girls, packers and curers alike. Our coastal villages depend largely upon the success of the herring season for their prosperity, and often the registrar's list of marriages may be gauged by the nature of the season—no herring no wedding.

WHITEBAIT.

In treating of the sprat and herring reference must be made to the whitebait. These consist of immature sprats and herring, the proportions varying according to the season and locality. In the Fourth Report of the Scottish Fishery Board is contained the results of an examination of the Thames Whitebait. The results are as follows:—

Month.	Number examined.	Percentage of herrings.	Condition of the herrings.
February	1,400	7	Some under 2 inches.
March	1,200	5	Some nearly 4 inches.
April	800	14	12 per cent. of the herrings under $1\frac{1}{2}$ inches without scales.
May	600	30	40 per cent. of the herrings 2 inches long and completely scaled; 60 per cent. $1\frac{1}{2}$ to $1\frac{3}{4}$ inches and only partly scaled.
June	800	87	60 per cent. of the herrings fully scaled 2 to $2\frac{1}{4}$ inches long; 40 per cent. 1 to $1\frac{1}{2}$ inches scaleless or nearly so.
July	600	75	$1\frac{1}{2}$ to $2\frac{1}{2}$ inches.
August	500	52	2 to 3 inches.

It is scarcely within our province to enter into the question of the wisdom of killing these immature fish, but one can hardly help remarking that if the immature fish were permitted to grow to maturity their market value would be enormously increased, and further, if they were allowed to breed, the resultant stock would be maintained at a high level.

V.—*Report of Delegates to the Centenary Meetings of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne.*

By HENRY COATES, F.S.A.Scot.

(Read March 14, 1930.)

My wife and I had the privilege of representing our Society at the Centenary Celebrations of the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne, which were held in the Hancock Museum, Newcastle, on Thursday, 17th October, 1929.

At the afternoon meeting the delegates were welcomed by the President, Viscount Grey of Fallodon, K.G., after which an address was delivered by Lord Armstrong, the patron of the Society, who gave a number of personal reminiscences of his own and his uncle's connection with the Society and the Museum in its earlier days. The delegates, to the number of about fifty, then went up to the platform in turn, and presented addresses of congratulation from the various Universities, societies, and other bodies which they represented. The address which our Society sent congratulated the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne on its long and distinguished career of usefulness, and expressed the hope that it might be enabled to carry on the good work for many years to come.

The evening meeting, which took the form of a conversazione, was also held in the large Bird Gallery of the Hancock Museum. In addition to the delegates, a large number of the members and of the leading townspeople had been invited.

The President, Viscount Grey of Fallodon, again occupied the chair, and delivered a most interesting address on some of his experiences in investigating bird life.

Professor A. Meek also gave an address on some of the famous naturalists who had helped to found the Society and the Museum. The address was illustrated with lime-light views showing portraits of these founders.

Not the least enjoyable part of the conversazione was the opportunity it gave for viewing the magnificent Natural History collections of the Hancock Museum. Altogether the meetings were most successful, and reflected great credit on the Secretary and the Curator, and their respective staffs.

VI.—*Recent Additions of* Cypræidae *and* Conidae *to the Conchological Collections in the Museum.*

By HENRY COATES, F.S.A.Scot.

(Read March 14, 1930.)

During my stay in Torquay last winter I was fortunate to make the acquaintance of Mr. W. M. Macandrew, the well-known conchologist, who lives at Dartmouth, on the south coast of Devon. Mr. Macandrew's late father was an equally famous conchologist, who added much to our knowledge of the mollusca of the West of Scotland.

Mr. Macandrew's collections, which fill cabinets lining all the walls of his billiard-room, contain many gems, some of which are almost, or altogether, unique. He has spent several seasons abroad in his yacht, in the Red Sea, the Philippine Islands, and other famous molluscan localities, dredging for shells. In this way he has been able to get specimens not only rare, but in prime condition, such as few other collectors possess. It was from these riches that he very kindly offered to select a small but choice collection of cones and cowries for our Museum, these being the groups in which he has specialised chiefly. I should add that his wife, Mrs. Macandrew, is a keen conchologist also, having specialised in the pectens, a group of bivalves, many of which are very beautiful.

The following is a list of the species he has given us which are new to our collections:—

2001. *Cypræa boivini.*
2002. *C. pulchra.*
2003. *C. walkeri.*
2019. *C. punctata.*
2004. *Conus taeniatus.*
2005. *C. obscurus.*
2006. *C. sumatrensis.*
2007. *C. terrebellum.*
2008. *C. auriciacus.*
2009. *C. achatinus.*
2010. *C. tendineus.*
2011. *C. lignarius* (with a white variety).
2012. *C. araneosus.*
2013. *C. aculminatus.*
2014. *C. sulcatus.*

2015. *C. minimus.*
2016. *C. varius.*
2017. *C. lithographicus.*
2018. *C. lucificus.*
118. *Cylinder textile*, var. *verriculum.*

Most of these are from the Red Sea and the Philippine Islands, and all were dredged by Mr. Macandrew himself.

In addition to these new species, Mr. Macandrew has sent us a remarkably fine series of the large spotted cowries, *Cypræa tigris* and *Cypræa pantherina*, from the Red Sea. These present a great variety of marking and colouration, from deep mahogany brown to pale cream colour. He has also given us exceptionally fine specimens of a number of other species that were already represented in the Museum.

Note on Carboniferous Fossils from Dollar.

By Henry Coates, F.S.A.Scot.

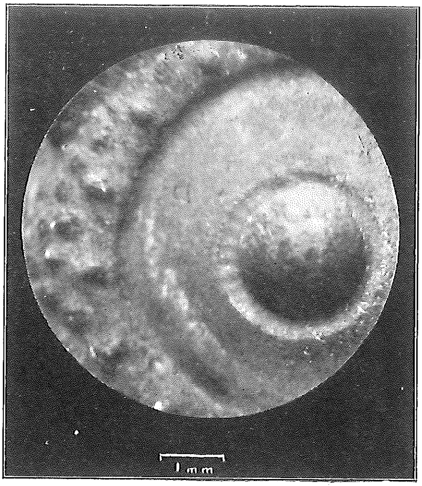
(Read by the Secretary, December 12th, 1930.)

The fossil Fauna and Flora of Perthshire are so meagre that it is of special interest to record a new discovery. Hitherto, the following, in ascending order, comprised almost all the known occurrences:—

1. The remains of algae, *Psilophyton princeps*, at Millhaugh Bridge, on the Almond, in beds of Lower Old Red Sandstone.
2. Remains of Fishes *(Holoptychius* and *Phyllolepis)* in the Upper Old Red Sandstone at Clashbennie, in the Carse of Gowrie.
3. Remains of *Cypris* and other bivalves in a small outcrop of Lower Carboniferous Shale at Dron, near Bridge of Earn.
4. Arctic shells from the Glacial Drift at Errol.

Recently some beautiful specimens of fossil ferns from the Carboniferous Limestone of the Dollar district have been presented by Mr. Syme, of Dollar, to the Museum. They were got at Middleton Farm and Kellyburn, on the Perthshire border, near Dollar, and have been identified by the officers of the Geological Survey (Scottish Office) as *Mariopteris muricata* (Schlok.) and *M. nervosa* (Brongn'art.). The former was got in a two-inch boring for an artesian well.

Another interesting palæontological find of an entirely different nature was got in a small flint nodule which was torn out of the ground when a tree was uprooted at Blackruthven, near Almondbank, during the storm of January, 1926. This nodule, which is about $1\frac{1}{4}$ inch in circumference, had been split at some time, displaying in its centre an inter-ambulacular plate



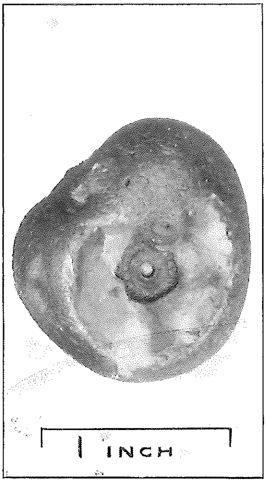
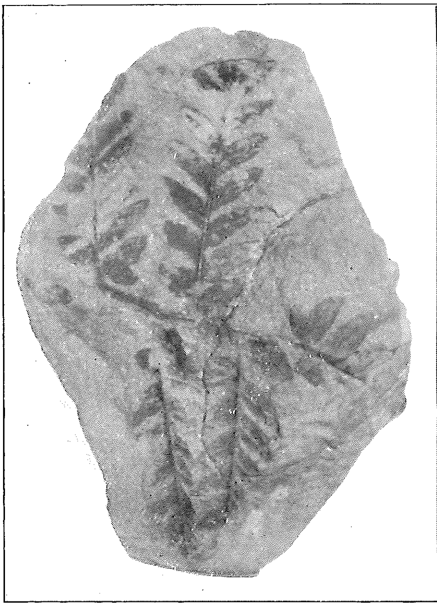
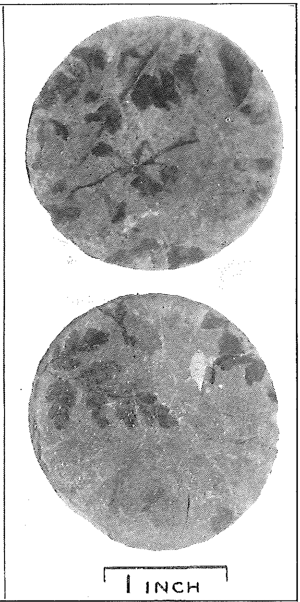


Photo Micrograph of Centre of Cidaris. Cidaris, in Flint.

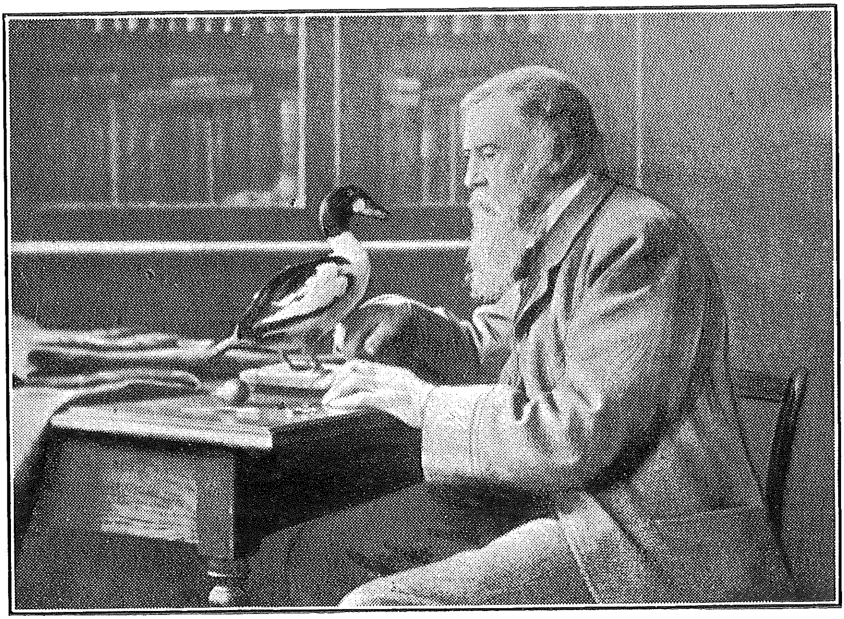
PLATE IX.





Mariopteris nervosa. M. muricata.

PLATE X.



Col. H. M. Drummond Hay, Seggieden.

PLATE XI.

of *Cidaris*, one of the Echinoderms, or sea-urchins. These flint nodules are of common occurrence in the Upper Chalk of England, but how this one found its way into Perthshire, where no chalk occurs *in situ*, it is hard to say. It may possibly have been transported by ice during the Glacial Period, or it may have been brought by Primitive Man during the Stone Ages, as material for his flint implements. It may even have been brought by man at a much more recent period. This specimen also has been identified by the officers of the Geological Survey.

I am indebted to Mr J. Ritchie for the Plate which accompanies this paper.

VII.—*Notes on Col. H. M. Drummond-Hay's Herbarium.*

By Surgeon-Captain C. G. Matthew, R.N.

(Read March 14, 1930).

Last year Mrs Drummond-Hay presented to our Society the extensive botanical and zoological collections of her late father-in-law, Col. H. M. Drummond-Hay of Seggieden.

At Mr Ritchie's request I undertook to go through and re-arrange the British part of the botanical section. There was handed over to me a dozen boxes, fashioned to imitate books, one or two of them hopelessly collapsed. They contained dried specimens, mounted on 11″ x 6½″ sheets. Then came innumerable bundles wrapped up in newspapers, containing loose unmounted specimens of all ages, back to the "fifties"—some labelled, some not—some in good condition, others moth-eaten and well-nigh unrecognisable. They had been collected in all parts of the British Isles, either by himself or his friends.

Colonel Drummond-Hay was born at Bath in the year 1814, and joined the 42nd Regiment—the Black Watch—in 1832. Abroad he served in Bermuda, Halifax, the Ionian Islands and Malta. At home he was stationed at Edinburgh, Dumbarton, and Dublin.

He retired from the Army in 1852, and was appointed to the command of the Perthshire Militia, a post which he held, with great acceptance, for twenty years. He died in 1895. He was a good soldier, a great naturalist, and a great gentleman. The love for, and understanding of Nature were inborn in the man. Wherever he went, from the very start of his career, he noted, observed, and collected alike plant and bird and beast, his fine physique and athletic habits standing him in good stead in his wanderings.

He had an advantage, given to few scientists, of being a competent artist, as a remarkably fine series of water-colour drawings of Bermudian fish which he made very clearly demonstrates.

While serving in the Island of Malta he made a large collection of Mediterranean plants. These, which are included in Mrs Drummond-Hay's benefaction, are accompanied by complete data, and bound up in a handsome folio volume.

He is probably best known to most of us by his work on the birds of Perthshire; but with his zoological work and botanical work outside England I am not now concerned.

Having first got rid of obviously superfluous material, I turned my attention to the "Books," which bore gilt-lettered labels—"Herbal of British Plants." The volumes were numbered, but, the collection having been left incomplete, bore no indication of their contents. That omission I have now made good. The first four volumes—up to Rosaceae—contain a very nearly complete collection of the species of the included orders, all most carefully set out, mounted, and labelled, and in a perfect state of preservation. These indicate what the Colonel's intentions were in respect of the whole Herbarium; but unfortunately, for some unknown reason, probably want of time, these intentions were never fully carried out. From Rosaceae onwards the collection was patchy, a large proportion of the specimens being evidently temporary and without printed labels. He seems to have departed from the systematic advance shown in the early volumes and to have taken up and completed odd Genera and Orders more or less at random, e.g. Gentian, Primula, Liliaceae, Juncaceae, and Cyperaceae.

I filled up what blanks I could from his own loose specimens, and, when these failed, from my own herbarium—this with the concurrence of Mr Ritchie and the approval of the donor. We thought it more important to have the collection as representative as possible than to keep it purely as a memorial of Col. Drummond-Hay; the more especially as many of his specimens had not been gathered by him personally. He was a member of the Botanical Exchange Club, and had as correspondents several of the best-known botanists of his time. From these sources he acquired material from parts of England unvisited by himself.

In England the bulk of his own collecting seems to have been done in the South-West, with Bath, in Somersetshire, as centre. There is not a great deal from Ireland.

Most of his Scottish work was done, largely in company with Buchanan-White, in this county, and the collection of our Alpines is a fine one, though there are curious gaps, e.g. from Ben Lawers we find **Saxifraga cernua** but not **rivularis**; **Veronica alpina** but not **saxatilis.** From Ben Laoigh **Draba rupestis, Pyrola rotundifolia** and **Bartsia alpina** are absent. Such rarieties as **Thlaspi alpestris, Sagina Linnœi, Oxtytropis**

uralensis, and **campestris**, **Astragalus alpinus**, **Menzesia cœrulea**, **Gentiana nivalis** are well represented.

Amongst the Ferns are both **Woodsias**, **Cystopteris montana**, and **Asplenium septentrionale**, but, unfortunately, not **germanicum**. He was also familiar with Clova and Glen Dole in Forfarshire.

Amongst the lowland Scottish plants I may mention **Lathyris niger**, **Pyrola uniflora**, **Cicuta virosa**, **Polygonatum verticellatum**, **Potamogeton Sturrockii**, **Scheuchzeria palustric** from Methven Bog, where it has become extinct within recent years, and **Naias flexilis** from Loch Cluny, where Col. Drummond-Hay discovered it in 1872—a first record for Scotland.

Curious omissions are **Linnœa borealis**, **Cynoglossum montanum**, and **Lysimachia thyrisiflora**, local specialities with which he must have been familiar.

From south of the Border there is a fine series of the Batrachian **Ranunculi**, and a practically complete set of the **Verbascums**. **Liliaceae** are specially good, and include such rarities as **Smilacina**, **Muscari**, and **Tulipa**. From the New Forest in Hampshire come **Gladiolus communis** and **Spiranthes œstivalis**, both extremely rare—the latter now possibly extinct.

My own contributions are mostly from the county of Kent, and include **Lathyris maritima**, **Peucedanum officinale**, **Senecio palustris** and **Orobanche caryophyllacea**.

Apart from the main Herbarium, to which these remarks apply, there is a separate and smaller one containing only the plants of the Carse of Gowrie, completed in the year 1873. The sheets, which are bound up in two calf volumes, measure 17½″ x 10″, and carry two or more specimens each. They are all in excellent condition, and many of them still retain their natural colours.

These few remarks will have served their purpose should they direct the attention of the members to this remarkable Herbarium, and to the opportunity therein afforded for the study and comparison of species outside their own range of country.

It is an unusually valuable and extensive collection, comprising flowering plants, grasses, ferns, lichens, mosses, and fungi, all represented by beautifully prepared specimens, accurately named, localized, and dated.

I hope that all who take interest in wild flowers will show their appreciation of Mrs Drummond-Hay's generous gift by making full use of it.

VIII.—*Note on* Saxifraga rivularis *in Perthshire.*

By William Young.

(Read March 14, 1930.)

I think Dr. Buchanan White mentions in his Flora of Perthshire that *Saxifraga rivularis* has been recorded from one station only—Ben Lawers. I was there last July along with some other members of the British Bryological Society. We saw one solitary plant of this very rare species. However, when ascending Ben More on 5th August, we came across several small plants without inflorescence. Not one was taken, so I have no specimen to show you, but no doubt the botanists of your Society will be interested to learn of this new station.

IX.—*The Natural History of the Firth of Tay*

By W. B. ALEXANDER, M.A.

(Read December 12th, 1930).

The study of the fauna and flora found below high-tide level in the Firth of Tay was undertaken by the writer in the summer of 1930, with the object of obtaining results for comparison with the results of similar work in the estuary of the River Tees. He was at the time Superintendent of the Tees Estuary Survey of the Marine Biological Association of the United Kingdom. The Tees Estuary Survey was undertaken by the Marine Biological Association at the request of the Department of Scientific and Industrial Research. It forms part of the scheme of the Water Pollution Research Board of the Department for the study of the Tees as a typical river receiving pollutions of various kinds, and, with the other investigations being carried out on the Tees and its tributaries, is under the direction of the River Tees Survey Committee. The writer is indebted to the Committee for permission to publish the biological results of his survey of the Firth of Tay in a journal where they will be accessible to local naturalists. He has also to acknowlegde the very valuable help he received during the survey from Mr. Frank Brady, his assistant in biology.

Acknowledgment is also gratefully made to Messrs. G. D. and W. R. Malloch, of Perth, and to Baillie Melville and numerous employees of the Tay Salmon Fisheries Co., Ltd., at Newburgh, Fife, and at Tayport, for their assistance and interest in the work. Mr. J. Ritchie, Curator of the Perth Museum, kindly gave facilities for identifying many of the specimens obtained and himself identified the leeches and certain other species collected

Since the principal object of this biological survey of the Firth of Tay was to compare the distribution of animals and plants in an unpolluted estuary with their distribution in the polluted estuary of the Tees, the collections were confined to the southern shores of the Firth, since it seemed possible that the northern shores might be somewhat polluted by effluents from the City of Dundee. Above the point of confluence of the Rivers Tay and Earn collections were made in the tidal portion of the Earn instead of the Tay, since it seemed possible that the Tay might be polluted by the sewage and effluents of the City of Perth. Below Tayport the southern shore consists of sand-banks only partly exposed at low tide and in this lowest section of the estuary collections could ony be made on the north shore at Buddon Ness.

For the purposes of the survey the Firth of Tay, from Bridge of Earn to the Abertay Lightship, was divided into 13 sections, each 2½ miles in length. Shore-collections were made at least once in each of these sections during low spring tides and hauls with a naturalist's dredge were made in all those in which the bottom allowed of the working of the dredge. In many places between Newburgh and the Tay Bridge the sandy bottom was so soft and the sand was so piled up into such high ridges by the rapid currents that dredging proved impossible. In the River Earn, on the other hand, dredging was impossible on account of the rocks, stones and snags on the bottom.

In the table below, setting out the distribution of each species as far as it was determined :—

B indicates dredged from the bottom.

T indicates obtained by shore-collecting.

In the case of the three first sections, in the River Earn, species which were actually found submerged at low-tide, though obtained from the shore, have been market BT, since in most cases it is certain that they would have been obtained by dredging if this had been possible.

The 13 sections into which the Tay estuary was divided are as follows :—

	Dist. from Abertay Lt.-ship in miles.	Localities included.
A	32½—30	Bridge of Earn.
B	30 —27½	Mouth of R. Farg.
C	27½—25	Mouth of R. Earn.
D	25 —22½	Newburgh.
E	22½—20	Ballinbreich Castle.
F	20—17½	Durward's Scalp.
G	17½—15	Birkhill Pier.
H	15 —12½	Balmerino.
I	12½—10	Wormit. Tay Bdge.
J	10 — 7½	Tayside Lighthouses.
K	7½— 5	Tayport, Pile Light.
L	5 — 2½	Abertay Sands.
M	2½— 0	Buddon Ness.

	A	B	C	D	E	F	G	H	I	J	K	L	M
PISCES—TELEOSTEI.													
Cottus scorpius ...	...	...	...	...	...	...	...	...	T	...	...	B	...
Agonus cataphractus	...	...	...	...	...	...	...	...	...	...	B	...	B
Lophius piscatorius...	...	...	...	...	...	...	...	...	T	...	...	T	...
Gobius pictus	...	...	...	...	...	T	BT	...	...	...	...	...	...
Pholis gunnellus ...	...	...	...	...	...	...	...	...	T	T	...	B	...
Ammodytes tobianus	...	...	...	...	...	...	...	...	...	...	T	...	B
Pleuronectes platessa	...	...	...	...	...	...	...	...	...	...	...	...	B
Pleuronectes flesus ...	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
Anguilla vulgaris ...	BT	BT	BT	...	BT	T	T	T	T	T	...	...	...
ASTEROIDEA.													
Asterias rubens ...	...	...	...	...	...	...	...	...	...	T	BT	BT	B
Solaster papposus ...	...	...	...	...	...	...	...	...	...	...	...	...	B
LAMELLIBRANCHIATA													
Mytilus edulis ...	...	...	...	...	...	...	...	...	BT	BT	BT	BT	BT
Modiola modiolus	...	...	...	...	...	...	...	...	...	...	...	B	...
Spisula solida	...	...	...	...	...	...	...	...	...	...	...	...	B
Tellina tenuis ...	...	...	...	...	...	...	...	...	...	...	...	...	T
Macoma baltica ...		...	...	...	...	...	...	T	...	...	...	...	...
Mya arenaria ...	...	...	...	...	...	...	T	T	...	...	...	...	...
Cardium edule ...	...	...	...	...	...	...	...	...	...	...	T	BT	...
AMPHINEURA.													
Chiton ruber	...	...	...	...	...	...	...	...	...	...	...	B	...
Craspedochilus cinereus	...	...	...	...	...	...	...	...	...	T	T	B	...
GASTROPODA.													
Goniodoris nodosa ...	...	...	...	...	...	...	...	...	...	...	...	B	...
Lamellidoris bilamellata ...	...	...	...	...	...	...	...	...	...	T	...	...	...
Acmaea testudinalis	...	...	...	...	...	...	...	...	...	...	...	B	...
Patella vulgata... ...	...	...	...	...	...	...	...	...	...	T	T	...	...
Gibbula cineraria ...	...	...	...	...	...	...	...	...	...	...	...	B	...
Buccinum undatum	...	...	...	...	...	...	...	...	...	B	B	B	...
Purpura lapillus ...	...	...	...	...	...	...	...	...	...	T	T	T	...
Littorina littorea ...	...	...	...	...	...	...	...	...	T	BT	T	T	T
Littorina obtusata ...	...	...	...	...	...	...	...	...	T	T	T	...	...
Paludestrina jenkinsii	...	BT	BT	T	T	T	...	...	...	...	...	...	...
Limnaea peregra ...	BT	BT	BT	T	...	...	...	...	...	...	...	...	...
Ancylus fluviatilis ...	BT	BT	BT	T	...	...	...	...	...	...	...	...	...
POLYZOA.													
Membranipora pilosa	...	...	...	...	...	T	BT	T	BT	BT	BT	B	BT
Alcyonidium hirsutum	...	...	...	...	...	...	...	...	T	T	...	B	...
Gemellaria loricata ...	...	...	...	...	...	...	...	...	...	...	...	...	B
CRUSTACEA—BRACHYURA.													
Carcinus maenas ...	...	...	...	...	...	T	BT	T	T	BT	BT	BT	B
Hyas araneus ...	...	...	...	...	...	...	...	...	...	...	...	...	B
Porcellana longicornis ...	...	...	...	...	...	...	...	...	...	...	...	...	B

	A	B	C	D	E	F	G	H	I	J	K	L	M
CRUSTACEA—MACRURA.													
Eupagurus bernhardus ...	...	...	...	...	...	...	...	...	...	...	...	B	B
Crangon vulgare ...	...	...	...	...	...	T	BT	T	T	...	...	T	B
CRUSTACEA—SCHIZOPODA.													
Neomysis vulgaris ...	...	...	...	T	...	T	B	...	...	...	...	T	...
CRUSTACEA—ISOPODA.													
Idothea pelagica ...	...	...	...	...	...	...	...	...	...	T	T	BT	B
Idothea baltica ...	...	...	...	...	...	...	...	...	...	...	T	...	B
Eurydice pulchra ...	...	...	...	...	...	...	...	...	T	...	...	...	...
Jaera marina	...	...	...	...	...	T	T	T	T	T	T	...	...
Ligia oceanica ...	...	...	...	...	...	...	T	T	T	...	T	...	...
CRUSTACEA—AMPHIPODA.													
Orchestia littorea ...	...	...	...	...	...	...	...	...	T	...	...	...	...
Sulcator arenarius ...	...	...	...	...	...	...	T	...	...	...	...	...	T
Atylus swammerdammi	...	...	...	...	...	...	...	...	...	...	...	...	B
Ammathilla sabini ...	...	...	...	...	...	...	...	...	...	...	...	B	...
Amphithoe littorina	...	...	...	...	...	...	...	...	...	...	T	...	...
Gammarus marinus	...	...	...	...	...	T	BT	T	BT	BT	BT	BT	B
Gammarus locusta ...	...	...	...	...	...	...	T	T	T	T	T	B	B
Gammarus pulex ...	BT	BT	BT	T	T	...	...	...	...	...	...	...	...
Corophium longicorne	...	...	...	BT	T	T	T	T	...	...	...	B	...
Caprella linearis ...	...	...	...	...	...	...	...	...	...	...	...	B	...
CRUSTACEA—CIRRIPEDIA.													
Balanus balanoides	...	...	...	...	...	...	...	T	BT	BT	BT	T	T
PYCNOGONIDA.													
Nymphon brevirostre.	...	...	...	...	...	...	...	...	...	...	...	B	...
INSECTA—DIPTERA.													
Tanytarsus sp. larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
INSECTA—TRICHOPTERA.													
Hydropsyche sp. larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
Polycentropus sp. larva	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
Stenophylax sp. larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
Sericostoma sp. larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
Lepidostoma hirtum larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
Leptocerus sp. larva	BT	...	...	...	...	...	...	...	...	...	...	...	...
Silo nigricornis larva	...	...	BT	...	...	...	...	...	...	...	...	...	...
INSECTA—EPHEMEROPTERA.													
Ecdyurus sp. larva ...	BT	...	...	...	...	...	...	...	...	...	...	...	...
Ephemerella ignita larva	BT	BT	...	...	...	...	...	...	...	...	...	...	...

	A	B	C	D	E	F	G	H	I	J	K	L	M
INSECTA— PLECOPTERA.													
Protonemura sp. larva	...	BT	...	...	...	...	...	...	...	...	...	...	...
POLYCHAETA.													
Lepidonotus squamatus ...	...	...	...	...	...	...	...	...	...	...	T	...	...
Harmothoe imbricata	...	...	...	...	...	...	...	...	...	...	...	B	...
Halosydna gelatinosa	...	...	...	...	...	...	...	...	...	...	T	...	...
Phyllodoce sp.	...	...	...	...	...	...	...	...	...	T	...	BT	...
Nereis pelagica ...	...	...	...	...	...	...	...	...	B	...	T	B	T
Nereis virens ...	...	...	...	...	...	...	...	...	T	...	...	...	...
Nereis diversicolor ...	...	...	...	...	...	T	T	T	T	...	...	...	...
Nephthys caeca ...	...	...	...	...	...	...	B	...	...	...	BT	T	...
Nephthys hombergi ...	...	...	...	...	...	...	...	...	...	...	...	T	T
Scoloplos armiger ...	...	...	...	...	...	...	...	...	...	...	T	...	...
Nerine cirratulus ...	...	...	...	...	...	...	...	...	...	...	...	T	T
Magelona papillicornis ...	...	...	...	...	...	...	...	...	...	...	T	...	...
Lanice conchilega ...	...	...	...	...	...	...	...	...	...	...	T	T	...
Amphicteis gunneri...	...	...	...	...	...	...	...	...	...	...	...	T	...
Ophelia limacina ...	...	...	...	...	...	...	...	...	B	B	...	B	...
Arenicola marina ...	...	...	...	...	...	...	...	T	T	...	T	T	...
Pomatoceros triqueter	...	...	...	...	...	...	...	...	...	...	T	...	...
OLIGOCHAETA.													
Limnodrilus hoffmeisteri ...	BT	...	BT	T	T	...	...	...	...	...	...	...	...
Psammoryctes costatus	...	...	...	...	...	...	...	...	...	...	T	T	...
HIRUDINEA.													
Herpobdella octoculata	...	...	...	T	...	...	...	...	...	...	...	...	...
Herpobdella stagnalis	...	...	...	T	...	...	...	...	...	...	...	...	...
Glossosiphonia complanata ...	...	BT	BT	T	...	...	...	...	...	...	...	...	...
NEMERTINI'													
Cerebratulus fasciolatus ...	...	...	...	...	...	...	...	...	...	...	...	T	...
TURBELLARIA.													
Dendrocoelum lacteum	BT	BT	BT	...	T	...	...	...	...	...	...	...	...
Planaria sp.	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
ANTHOZOA.													
Actinia equina... ...	...	...	...	...	...	...	...	...	...	T	T	...	...
Cylista undata ...	...	...	...	...	...	...	...	...	T	T	...	T	...
Urticina felina ...	...	...	...	...	...	...	...	...	...	T	...	...	...
HYDROZOA.													
Clava multicornis ...	...	...	...	...	...	...	...	...	B	...	...	...	...
Cordylophora lacustris	...	...	...	T	BT	T	...	...	...	...	...	...	...
Obelia geniculata ...	...	...	...	...	...	...	...	...	B	...	...	B	B
Obelaria gelatinosa ...	...	...	...	...	B	T	BT	...	T	...	...	...	...

	A	B	C	D	E	F	G	H	I	J	K	L	M
Sertularia pumila ...	...	...	...	...	...	...	...	...	...	T	BT	...	...
Plumularia falcata	...	...	...	...	...	...	...	...	...	...	...	B	B
PORIFERA.													
Halichondria panicea	...	...	...	...	...	...	...	...	...	B	B	...	...
Ephydatia fluviatilis	BT	BT	...	T	...	...	...	...	...	...	...	...	...
ALGAE—CHOLOROSPERMEAE													
Enteromorpha compressa ...	...	...	...	T	T	T	T	T	T	T	BT	T	T
Enteromorpha intestinalis ...	...	...	...	...	T	T	...	...	...	T	BT	T	...
Ulva lactuca	...	...	...	...	...	T	T	T	T	T	T	BT	T
Cladophora sp. ...	T	T	...	T	T	T	T	T	T	...	T	...	...
Vaucheria piloboloides ...	T	...	...	...	T	T	...	T	...	...	...	...	...
ALGAE—FUCOIDEAE													
Desmarestia aculeata	...	...	...	...	...	...	...	...	...	...	T	BT	BT
Pylaiella litoralis ...	...	...	...	...	...	...	...	...	T	...	T	T	T
Chorda filum	...	...	...	...	...	...	...	...	...	...	T	...	...
Laminaria saccharina	...	...	...	...	...	...	...	...	...	...	BT	BT	BT
Ascophyllum nodosum	...	...	...	...	...	...	...	T	T	T	T	...	...
Fucus ceranoides ...	...	...	...	...	...	...	T	T	T	T	T	...	...
Fucus vesiculosus ...	...	...	...	...	...	T	T	T	T	T	T	T	T
Fucus serratus... ...	...	...	...	...	...	...	...	...	T	T	T	...	...
Pelvetia canaliculata	...	...	...	...	...	...	T	T	T	T	T	...	...
ALGAE—FLORIDEAE													
Porphyra vulgaris ...	...	...	...	...	...	...	...	T	T	T	T	T	T
Batrachospermum moniliforme ...	BT	...	...	...	...	...	...	...	...	...	...	...	...
Lemanea fluviatilis	BT	...	...	...	...	...	...	...	...	...	...	...	...
Gigartina mamillosa	...	...	...	...	...	...	...	...	...	T	T	...	...
Rhodymenia Palmetta	...	...	...	...	...	...	...	...	T	T	T	...	...
Delesseria sanguinea	...	...	...	...	...	...	...	T	...	...	T	B	B
Polysiphonia fastigiata	...	...	...	...	...	...	...	...	T	T	T	...	...
Ptilota plumosa ...	...	...	...	...	...	...	...	...	...	...	...	...	B
Ceramium sp.	...	...	...	...	...	...	...	...	T	T	T	...	BT
MUSCI.													
Eurhynchium rusciforme ...	BT	BT	BT	BT	...	...	...	...	...	...	...	...	...
Fontinalis antipyretica ...	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
MONOCOTYLEDONES.													
Zostera marina ...	...	...	...	...	...	...	...	...	...	...	B	T	...
Potamogeton crispus	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
Triglochin maritimum ...	...	...	...	T	T	T	...	...	...	...	...	...	...
Elodea canadensis ...	BT	...	...	...	...	...	...	...	...	...	...	...	...
Juncus articulatus ...	T	T	...	...	...	...	...	...	...	...	...	...	...
Juncus Gerardi ...	...	...	...	T	T	T	...	T	...	...	...	...	...
Scirpus lacustris ...	...	T	T	T	T	T	...	...	...	...	...	...	...
Scirpus maritimus ...	...	...	...	T	T	T	...	T	...	...	...	...	...
Glyceria aquatica ...	T	T	...	...	...	...	...	...	...	...	...	...	...
Arundo Phragmites	T	T	T	T	T	T	...	T	...	...	...	...	...

	A	B	C	D	E	F	G	H	I	J	K	L	M
DICOTYLEDONES.													
Ranunculus fluitans	BT	...	...	...	...	...	...	...	...	...	...	...	...
Sagina maritima ...	...	...	...	...	...	...	...	T	...	...	...	...	...
Myriophyllum spicatum	BT	BT	BT	...	...	...	...	...	...	...	...	...	...
Aster Tripolium ...	...	...	...	T	T	T	...	T	...	...	...	...	...
Glaux maritima ...	...	...	...	T	T	...	...	T	...	...	...	...	...
Veronica Beccabunga	T	...	...	...	...	...	...	...	...	...	...	...	...
Plantago maritima	...	...	...	...	...	...	...	T	...	...	...	...	...
Polygonum Hydropiper ...	T	...	...	...	...	...	...	...	...	...	...	...	...
Callitriche stagnalis	T	T	T	T	...	...	...	...	...	...	...	...	...
Callitriche intermedia	...	...	BT	...	...	...	...	...	...	...	...	...	...

List of Aquatic Birds Observed in the Firth of Tay by W. B. Alexander.

(*August 22nd—September 11th, 1930*).

CORMORANT (*Phalacrocax carbo*). Frequent up to Balmerino.

MUTE SWAN (*Cygnus olor*). Common from Broughty Ferry to Newburgh, occasionally down to Buddon Ness and up to Bridge of Earn.

[WHOOPER SWAN (*Cygnus cygnus*). One seen at the Mouth of the Earn in October, 1929.]

[SHELDRAKE (*Tadorna tadorna*). Common between Tayport and Newburgh in June, 1930.]

MALLARD (*Anas boscas*). Frequent above the Tay Bridge, common on the Earn.

TEAL (*Querquedula crecca*). One flying near Newburgh 11th September, 1930.

EIDER DUCK (*Somateria mollissima*). Extremely numerous along the Abertay Sands over the mussel-beds, occasionally up to Tay Bridge.

COMMON SCOTER (*Oedemia nigra*). A small flock at Buddon Ness 1st September, 1930.

GOOSANDER (*Mergus merganser*). Three on Abertay Sands 1st September, 1930.

RED-BREASTED MERGANSER (*Mergus serrator*). One near Birkhill 28th August, 1930.

HERON (*Ardea cinerea*). Frequent from Abertay Sands to Newburgh.

DUNLIN (*Tringa alpina*). One at Tayport 8th September, 1930.

SANDERLING (*Calidris arenaria*). A flock at Buddon Ness 1st September, 1930.

REDSHANK (*Totanus totanus*). Frequent between Abertay Sands and Newburgh.

GREENSHANK (*Totanus nebularius*). One on the banks of the Earn about 3 miles from its mouth 9th September, 1930.

BAR-TAILED GODWIT (*Limosa lapponica*). Two on the beach near Buddon Ness 29th August, 1930.

CURLEW (*Numenius arquata*). Plentiful on Buddon Ness and Abertay Sands, frequent up to Newburgh.

RINGED PLOVER (*Aegialitis hiaticula*). Two near Birkhill 28th August, 1930.

LAPWING (*Vanellus vanellus*). Plentiful near Newburgh and on the R. Earn.

OYSTERCATCHER (*Haematopus ostralegus*). Extremely abundant on Abertay Sands and at Buddon Ness, occasionally up to Tay Bridge.

TURNSTONE (*Arenaria interpres*). One near Tayport 8th Sept., 1930.

SANDWICH TERN (*Sterna sandvicensis*). Common from Buddon Ness and Abertay Sands to Balmerino, occasionally to Birkhill, still present 11th September, 1930.

COMMON TERN (*Sterna hirundo*). A few between Tayport and Balmerino in August.

ARCTIC TERN (*Sterna paradisea*). Some between Tayport and Balmerino in August. Neither of these species in Sept.

[LITTLE TERN (*Sterna minuta*). Seen near Tayport in June, 1930.]

BLACK-HEADED GULL (*Larus ridibundus*). Abundant from Tayport to Newburgh ; common down to Buddon Ness and up to Bridge of Earn.

COMMON GULL (*Larus canus*). Abundant to Newburgh.

HERRING GULL (*Larus argentatus*). Common to Balmerino, occasionally to Newburgh.

GREAT BLACK-BACKED GULL (*Larus marinus*). Plentiful below the Tay Bridge, occasionally to Newburgh.

LESSER BLACK-BACKED GULL (*Larus fuscus*). Occasional between Tay Bridge and Newburgh.

KITTIWAKE (*Rissa tridactyla*). Two below Broughty Ferry 5th September, 1930.

POMARINE SKUA (*Stercorarius pomarinus*). A few below Tayport.

ARCTIC SKUA (*Stercorarius parasiticus*). Some below Tayport.

RAZORBILL (*Alca torda*). One off Buddon Ness 5th September, 1930.

GREAT NORTHERN DIVER (*Colymbus immer*). One off Abertay Sands 5th September, 1930.

MOORHEN (*Gallinula chloropus*). Common on R. Earn.

COOT (*Fulica atra*). Flock near Lucky Scalp 5th and 8th Sept., 1930. One near Birkhill 28th August, 1930.

X.—*Notes on a Boulder found in the Excavations on the New Academy Site at Perth.*

With Plate No. XII.

By G. F. Bates, B.A., B.Sc.

(Read December 12th, 1930.)

During the excavations in the glacial deposits for the foundations of the new Academy, a boulder of considerable interest was found. It is a mass of fine-grained igneous rock, of somewhat irregular shape—roughly speaking, a pyramid on a convex base. The diameter at the widest part is approximately one foot: the pyramidal part is about 15 inches in length, and the over-all length about 20 inches. Externally, the boulder is of a rusty brown colour, owing to the oxidation of the iron compounds present in the rock, and traces of spheroidal weathering are visible. A freshly broken surface is of a dark grey colour, and this, together with the external colour and spheroidal weathering, shows that the rock is of the basic type, while the presence of quartz, to be noted later, shows that the basicity is not extreme. The most interesting feature, however, is that the boulder has been cracked, and separates readily into two portions. One surface of the crack is broken up into short columnar pieces, four-sided, or polygonal, in section, while the other shows a series of corresponding depressions fitting the somewhat convex surfaces of the columns. Further examination shows that the columnar pieces may be readily detached from the surface to which they adhere; we have thus a layer of short columnar—almost tabular—pieces, separating the two main portions of the boulder.

In my opinion, this peculiar structure has arisen in a quite simple way. By the action of natural agencies, a piece has been broken off from an exposed portion of the original rock-mass, and this has been transported by ice, along with a heterogeneous mass of other fragmentary materials, to the place where it was found. During its travels, the boulder would be subjected to various stresses as it was moved along by the action of the ice, possibly under the pressure of a great depth of this material. Ultimately the boulder would be reduced to its present size and shape, while, at a place corresponding perhaps to an original line of weakness, a crack had been developed, but the two parts had not been separated.

The infiltration of water during long centuries would, I think, account for the rest. It is a well-known fact that basic igneous rocks tend to develop a columnar structure on cooling, as may be seen in the dolerites at N. Queensferry and elsewhere. The columns are approximately at right angles to the larger surface of the rock-mass, *i.e.*, in a vertical dyke they are horizontal, in a horizontal bed they are vertical. The columns are due to the strains set up by contraction on cooling, and it is conceivable that the actual separation into columns might not take place until a certain degree of weathering had taken place along the planes where the state of strain existed. Such was perhaps the case with the specimen under consideration. Water percolating would tend to diffuse into the body of the rock at right angles to the crack, and to cause the rock to weather along planes of weakness already existing, and thus to reveal the latent columnar structure.

It would be of interest to trace the source from which the boulder may have come, but this would be a very difficult task. If we accept Geikie's Map of the Glaciation of Scotland, the evidence would point to the North-West as the direction from which the boulder had come. But in this direction, especially after the Highland fault has been crossed, there is an almost endless variety of dykes and sills of igneous rocks, and none of those that I have examined correspond to this particular rock. On the other hand, the boulder may have been brought by some local eddy in the ice-flow, and if that is the case, it may have come in almost any direction. On the whole, my preference would be for a Highland origin, in the absence of definite evidence to the contrary.

Microscopic examination of sections of the rock shows that it is composed of plagioclase felspars, and a pyroxene, as the principal constituents, along with hornblende and quartz—the latter not very abundant. Iron ores are conspicuous, and a few other accessory minerals may be detected. So many systems of nomenclature have been proposed that it is not easy to give a definite name. Dr. Innes is of the opinion that it is a quartz dolerite, and I do not know that a better term could be found. Reference may be made to Cole's "Aids in Practical Geology," 4th Edition, p. 230.

XI.—*Rare Plants.*

By E. H. M. Cox.

(Read January 9th, 1930.)

I fear that the title of my lecture is a little misleading. If you have come to see a number of slides of pretty plants and hear as few words as possible, you will be disappointed, for I have only a few slides and a great deal to say.

Some of my gardening acquaintances think that I am only interested in a plant if it is rare. That is not the case; but I have a very definite idea of what I personally think is beautiful and

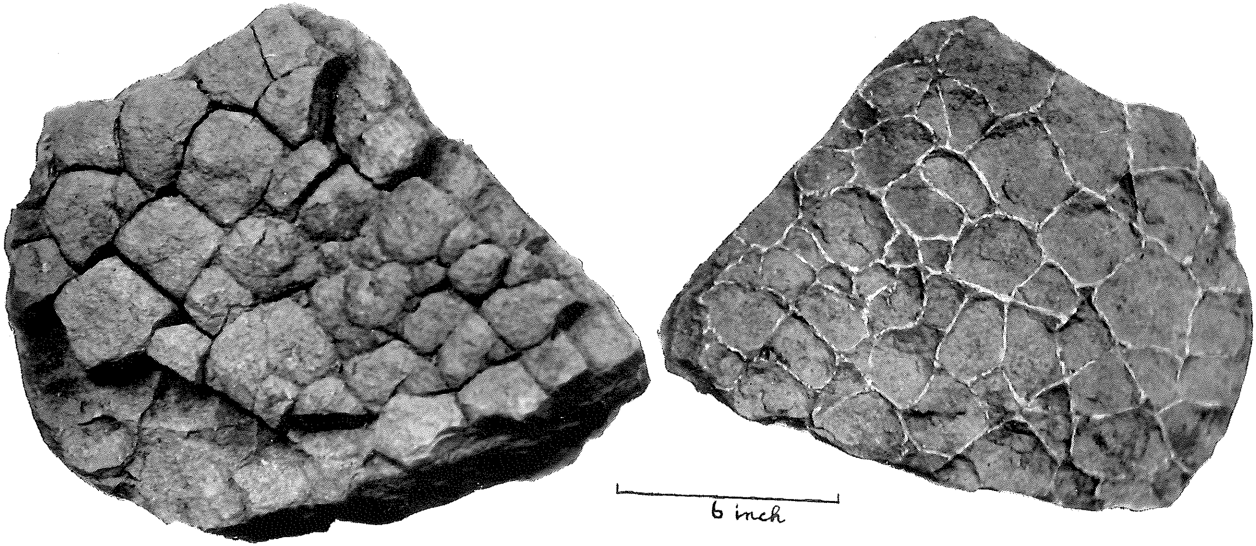


PLATE XII.

Boulder from Foundations of New Academy, showing Surfaces of Fracture.

what is not. I make no attempt to convert others to my views, as opinions of beauty in flowers is a personal thing with which no one has the right to interfere. However, I should like to prove to you that many rare plants are beautiful, and because they are rare is sometimes no reason why they should not be more often grown.

It is strange how like the gardening fraternity is to a flock of sheep; they follow the bell-wether, do the same thing day after day and month after month, and take fright at quite ridiculous obstacles. To my mind, half the fun in gardening is experimenting—but then I was born with an enlarged bump of curiosity. One of the reasons why many gardeners shy at the idea of experimenting with new or rare plants is their fear that they will have nothing to show their friends. But the careful experimenter is the man—or woman—who has a groundwork of plants which he knows and grows well. With them as a background he begins here and there with plants that are new to him. Those that succeed are added to the groundwork, and so it goes on. The gardener who attempts nothing but rarities is either of a scientific mind or is a collector. He would be just as happy with beetles, and probably has little or no eye for beauty.

So that you may see that I admire plants other than rarities, let me explain my idea of beauty in a plant on a percentage basis. Let me say that colour counts 25 per cent., beauty of habit and general effect 25 per cent., beauty of flower which means shape and the manner in which it is carried 25 per cent., beauty of the individual leaf 10 per cent., and the final 15 per cent. is for beauty of fruit, if that is worth considering. If that is absent, I add it on to beauty of habit.

Now let me take two common plants, the Rose which I love, the Gladiolus which I detest. I work out my percentage as follows in any good Rose:—Colour 25 per cent., beauty of habit 12½ per cent., beauty of flower 25 per cent., beauty of foliage 5 per cent., making in all 67½ per cent, a high average. With me the Gladiolus works out as follows:—Colour 25 per cent., beauty of habit nil; beauty of flower 10 per cent., beauty of foliage nil—in all 35 per cent. Probably few of you will agree with me, but I am giving you my personal opinion.

As this question of beauty has a great deal to do with the worth—or otherwise—in my eyes of rare plants, let me show you a few slides of commoner garden flowers which I consider beautiful:—

Rose Etoile de Hollande.
    Shot Silk.
    Mabel Morse.
Delphinium Mrs. Townley Parker.
Pyrethrum H. Robinson.
Clematis Nellie Moser.

Clematis montana.
Michaelmas Daisy (dislike).
Viburnum tomentosum plicatum.
Aethionema Warley.
Nepeta Mussini.
Lilium regale.
Dryas octopetala.
Ramondia pyrenaica.

Now in my work on my journal which is written for the more or less advanced gardener I constantly come up against the question: Why is a plant rare? The reasons are often complicated, but I have boiled them down to a rough classification:—

1. Because it is worthless apart from its rarity.
2. Because it is newly introduced or produced, and has not had sufficient time to spread into general cultivation, and also, in the case of trees and shrubs, its slow growth.
3. Because it is not hardy.
4. Because it is definitely difficult to grow, which is not the same thing as being non-hardy.
5. Because it is difficult to increase it either from cuttings or seed.
6. Because gardeners have not found out its likes and dislikes, which, as I shall explain later, is not always the same as being definitely difficult to grow.
7. Because the plant has not been sufficiently advertised.
8. Because it is so like something else already well known and perhaps better.
9. Because the plants are not fashionable.
10. For no known reason.

Now let me take each of these causes in detail with examples, many of them plants introduced from China by Farrer or Forrest. The first, because it is worthless apart from its rarity, is obvious. Unfortunately, plants almost every year are brought out with a flourish of trumpets of which they are not worthy. This is unfortunate for two reasons, the wasted energy and space in growing them, and because the gardener who buys, what in America is called a pup, is often shy of making further experiments.

The second, because it is newly introduced or of slow growth, is also obvious. Among this group are most of the magnificent new Rhododendrons sent home in the last two decades from China and Burma. Here is an example of slowness of growth, **R. basilicum*, that Farrer and I found. It will probably not flower for another ten years, at least so far north as this, although it is quite hardy when grown in a good position. The next, **R. dichroanthum*, has already flowered in the south, and will probably do so here within a couple of years. Now both of these shrubs take from 10-20 years to flower, and so they will always be rare, costly for the nurserymen to raise, and few gardeners have the space or patience to wait so many years for a plant to become productive. They are uneconomic except in the large garden, and must always be included among rare plants.

The third reason, because it is not hardy, is also obvious. It must be remembered that we can not only equal but surpass much of England, for instance round London, as regards actual hardiness, for plants go more thoroughly to sleep here, and so are often spared the devastating cuts from spring frost which are so common in the south. What we lack in the north is sufficient sun or heat to ripen plants and so make them produce flowers in quantity—but that is another matter. As example *Davidia involucrata,* Lilium regale.** Where plants verge on the definitely non-hardy, they are usually grown successfully only in Cornwall or Galloway, and they are of necessity rare because the areas are small and the demand is not great. As an example I show you **Manglietia insignis*, another of Farrer's plants from Upper Burma. It is a pity, as this plant gets almost maximum in my idea of beauty,, 25 per cent. for colour, 25 per cent. for habit, 25 per cent. for beauty of flower, 10 per cent. for beauty of leaf and 5 per cent. for beauty of fruit, in all 90 per cent., very high marks.

The fourth, because it is definitely difficult to grow, is often because the plants are high alpines which have a wet summer in their home, which we may be able to copy if last year was any criterion, and always sleep under a blanket of snow for six months which we can never give. They like their seasons' changes rung with the utmost regulartity and so our climate does not suit them. This applies to plants not only from China, but also from New Zealand, the Rockies, and the Andes. It has been proved on many occasions that they can be grown, but the care and trouble and patience that must be taken is more than is humanly possible, and sooner or later they pass away. Two examples I can show you, *Cremanthodium Delavayi**, a magnificient composite from China, and what is probably the finest of all Primulas, *P. sonchifolia**. This would get 80 marks.

The fifth, because it is difficult to propagate, is not always a lasting reason, as in many cases new methods of increase are found, particularly in striking cuttings. As an example I can give *Arctostaphylus manzanita*, a lovely ericaceous plant from California with evergreen leaves and hanging bells, not unlike those of a Pieris or Andromeda. For many years it was extremely scarce, as it was almose impossible to propagate until they found out at the R.B.G. that it would strike like a weed if only the tips of the shoots were taken, as in the heaths. Even now it is none too common, but that is through lack of advertising its beauty. Then again there is a charming little Primula, like *P. flexilipes*,* which grows well with me and is absolutely perennial, but it obstinately refuses to set seed, although we pollinate it in every possible way. I am afraid it will always be scarce. Even the collector has his troubles in collecting seed. Here is a slide of *Viburnum Wardii*,* called after its finder, Kingdon Ward. Farrer and I, and also Forrest, have found it in addition, and every collector complains that it sheds its seed within a few minutes of ripening, usually after the first fall of snow, and as the seeds are small no stock has ever been collected.

Next we come to plants that are finicky. Probably the best known example is *G. Farreri**. Mr Harley grows it marvellously at Glen Devon, but I have always failed with it. There is some minute difference in our soil or climate to which it takes exception. The same applies to Farrer's famous Kansu Lily, *L. centifolium**. In a few gardens they call it easy; in others, not so far distant, it is difficult. This applies to many Chinese Lilies, an old introduction *L. Brownii var Colchesteri**, the common Lily of Upper Burma and Western Yunnan has always been called, and is, difficult. I do not think it is a question of hardiness. That is where the experimenter comes in. Also *Nomocharis pardanthina var Farreri*.

7. Next we come to the reason, because it is not sufficiently advertised: *Eucryphia pinnatifolia** the white-stemmed *Rubus biflora**, *Buddleia alternifolia*[2]*, *Rhodo. calostrotum**.

8. Like something else—botanical difference.

9. Because the plants are not fashionable—old lace pinks, old Roses.

10. For no known reason—*Viburnum fragrans*, *Gentiana sino-ornata*.

XII.—*Supplementing Nature.*
Presidential Address.

By WILLIAM MALLOCH, B.Sc.

(Read March 13th, 1931.)

Perhaps no field of nature study offers greater opportunities for advancement of mankind than that of adapting nature's methods to suit man's needs. Nature is a bounteous if exacting mother, giving freely and lavishly of her fruits, not all of which, however, are palatable or necessary for our existence. Indeed, of some it may well be said that they are mere cumberers of the earth, retarding instead of advancing our activities. It is possible that these apparently unruly and perverse children of nature have indirectly a positive influence in maintaining a proper balance, and this aspect must not be overlooked. The farmer, for example, wages incessant warfare on the ubiquitous thistle, but it is well known that cattle and other animals thrive well if the grazing is supplemented by a small daily ration of freshly cut thistles. Again, but for the thistle the battle of Luncarty might well have gone against the Scots. There is, therefore, a place for almost all of nature's gifts, whether for apparent good or evil, but it is our duty to endeavour to keep each in its place. This aspect of the naturalist's activities was clearly demonstrated by Professor Peacock at our recent conversazione. The Professor gave a most instructive address on "The Naturalist Militant," in which he instanced how the biologist had successfully overcome plant and insect pests by discovering and breeding suitable parasites to prey on these pests.

It is not my purpose, however, to address you on this particular aspect of supplementing nature. I am concerned rather with the problem collateral to that of producing two blades of grass where formerly one grew. We know that by careful selection of pedigree seed the propagation of prolific crop bearers becomes a commercial success. The introduction of chemical fertilisers has effected both a saving of labour and a heavy increase in production of green and white crops. Many other important changes and improvements in the cultivation of the fruits of the soil may be quoted. Let me now turn to the harvest of the waters, and, in particular, to the possibilities of supplementing the stock of salmon by artificial or other methods.

Before attempting to assist nature, it is essential that we should have an intimate knowledge of her methods. Then we proceed to take advantage, not of nature herself, but of her processes. The probable effect of our intervention must be calculated, not merely upon the primary subject which we seek to develop, but also upon any other forms of life associated with it. Not so long ago grey squirrels were introduced into this country, and now they have multiplied so fast that it is well nigh impossible to arrest the serious havoc they are causing. The musk-rat, introduced into Germany for the sake of its pelt, has now overrun that country. Indeed, of late its introduction into Perthshire has presented us with a problem that has caused no little uneasiness at Carsebreck.

The effect upon Australia of the introduction of the rabbit and the thistle needs no elaboration. Our aim, therefore, must be to proceed upon well-thought-out lines and to embark on no enterprise whose ultimate effect cannot be foreseen. Nature is usually profligate where protection is scanty or non-existent. The number of eggs deposited by each species of fish will vary according to the risks to which they are exposed. The cod-fish lays over 9 million eggs. Being buoyant, they are subject to enormous loss. The salmon of, say, 12 lb. will lay round about 10,000 eggs, but they are protected to some extent by being covered up with gravel. If, therefore, we can eliminate some of the wastage and increase the protection of the eggs and young we shall have achieved something worth while. In attempting to redress the balance of nature we must be careful not to overdo it. If we upset this balance immediate and complete disaster may follow. Many years ago Loch Tulla was over-crowded with myriads of small, ill-conditioned trout. An effort was made to reduce the numbers, but, alas, though successful, the result was disastrous. Pike were introduced, and the weeding out was soon accomplished. The pike increased rapidly, and, conversely, the stock of trout diminished as quickly. But few trout can now be caught, though I am bound to say there is no complaint about the size. The problem is how to get rid of the pike.

The salmon industry of the British Isles is of very great importance and a source of considerable revenue to the country. The production exceeds that of all other countries in Europe put together, and every means of improving or maintaining the catch should be explored. Of late the question of artificial propagation on a large scale has come into prominence, and the determining factor will be its ultimate economic value. The solution will depend upon answers to the questions: Is it practicable, and will it pay? What we want to prove is whether man can do better than nature, and, if so, whether the benefit so derived can be definitely termed a financial gain. Let us first examine briefly nature's methods.

During the month of October the earliest of our spring fish begin to seek out their spawning grounds situated in the distant headwaters of the main tributaries. At short intervals their example is followed by the later runs, each in its turn, until by the end of November or early December the latest of the autumn fish are busily engaged on the spawning fords but a short distance above the tideway. At the initial stage there would appear to be, therefore, a reasoned orderliness in nature's methods. First of all, there is a successful endeavour to obtain a wide distribution of the spawning stock, so that the available spawning ground is neither unoccupied nor overcrowded. Secondly, the season of the year is so chosen as to suit best the needs of the ova and the resulting fry. Uniformity of temperature of the water is highly desirable during the incubation period, and this, as a rule, only obtains during winter. Again, the duration of the incubation period depends upon temperature, cold water delaying, and warm water hastening, hatching. The ova laid down in the headwaters takes longer to develop than that deposited in the lower reaches, since the higher up the river one goes the lower becomes the temperature of the water. It is extremely important that the hatching-out stage should not be reached before food of some sort is availabl' for the fry. Once the yolk sac is absorbed, the fry must fee or perish. Now, nature has so arranged it that the same causes which produce early hatching also provide an early food supply. The lowland streams are producing food whilst those of the uplands are but struggling to throw off the effects of the winter's frosts and snows. The most important of many deductions which may be drawn from these facts are that it is highly injudicious to stock the headwaters with early eyed ova or early hatched fry, and that in planting out the fry wide distribution is advisable.

It is a mistake to imagine that the spawning salmon select the spawning fords indiscriminately. Nothing could be further from the truth, for the choice is made with great selectivity. As a rule, one finds that the gravel is roughly of a uniform character, free from sediment, and stable. The stream or ford is rapid, thus assisting the digging process, and a uniform depth of water is usually maintained, except, perhaps, in high floods or very severe frosts. Certain inevitable losses occur during deposition of the ova. Some of it becomes scattered and remains uncovered, to be picked up by attendant trout and birds. Faulty impregnation of the ova takes place, and this is regarded as being the greatest source of loss. There is also a subsequent loss of fry when the sac is absorbed owing to the difficulty in finding or assimilating the natural food of the river. Too much stress has been laid on the possible losses due to severe floods or frosts. On the whole, the ova and fry emerge fairly safely from such possible causes of disaster. Nature has made wise provision against contingencies, and the fitness of the fry to survive is marvellous. Nevertheless, the loss due to lack of cover or faulty impregnation is great, and in this respect at least, man, by artificial hatching, can excel nature. At this stage the case for artificial propagation is almost overwhelming.

Perhaps one of the greatest difficulties encountered in artificial propagation is the collection of ova. The usual method adopted of netting spawning fish on the redds is extremely unreliable. Moreover, it is expensive, and too often the best and safest spawning grounds are harried in an ill-conceived endeavour to fill the hatchery. Spent, ripe, and unripe fish are caught indiscriminately; frequently ripe fish of the same sex only are found. In addition, the rough handling in the net leads to abrasion of the fish and consequent liability to outbreak of disease. In some districts the unripe fish are penned in crates or "corfes" until the fish are ready to be stripped, but in spite of all precautions losses occur. By far the most successful method, commercially, is to provide ponds in which the salmon can be retained for several weeks, or, it may be, months, until ripe. Such an undertaking, however, is only worth while if carried out on a large scale or in conjunction with an auxiliary business, such as a trout hatchery. In this way overhead charges may be reduced to a minimum, and should serious mortality of the stock occur, there will have been at least some saving in labour costs.

The next step of hatching out the ova is straightforward, and as a rule most successful. In properly conducted hatcheries a hatch of 95 per cent. of the ova laid down is regularly attained. This side of the hatchery business is highly developed, and as near as can be 100 per cent. efficient. The next stage is the most critical of all in artificial development of salmon. The whole fabric of hatchery practice depends upon the results obtained in planting out the fry. In this country there is no method of ascertaining, even approximately, the losses which occur when the fry have been returned to their proper habitat. If the fry are retained in the hatchery boxes until the yolk sac is absorbed, severe losses occur in the transition stage between the alevin and the fry proper. If the alevins are planted out, their semi-helpless state renders them an easy prey to enemies of all kinds. In both cases the process of acclimatisation to their new environment is accompanied by heavy loss. There can be little doubt that at this stage at least the natural method is much more effective. Indeed, for this and other reasons it is the usual practice in America to sow eyed ova in prepared redds or boxes in the streams so that there is no abrupt change of environment. Where this cannot be done, and resort must be made to stocking with fry, the best results are obtained by turning out the fry about a fortnight before the yolk sac is absorbed. The ultimate aim of all processes, natural or artificial, is the production of smolts. By artificial propagation we can produce more fry, but this alone is insufficient to justify the creation of gigantic hatcheries to supplant natural methods. We must estimate our results in terms of smolts. Since it is well known that brown trout can be reared successfully to the yearling or two-year-old stage in such a manner as to be a paying proposition, one is tempted to think that the rearing of smolts would be equally successful. This is not so, however. For one thing, the salmon parr is not so hardy and does not respond so well to artificial feeding. By very careful management and special attention, it might be possible to produce smolts at a figure of £50 per thousand, which is not much in excess of the price of two-year-old trout. When trout are introduced into lochs and streams they remain there, or are kept there by mechanical contrivances, and are soon available for sport. Smolts, on the other hand, descend to sea, and out of every thousand only some fifty or thereby survive to return to their native haunts. It is obvious, therefore, that the cost is prohibitive, as each returning salmon of the original batch of artificially reared smolts will have cost twenty shillings to produce, and is now worth little more, it may be something less. This process reminds one of the description of a pheasant covert shoot: "Up goes a guinea, bang goes tuppence, and down comes half-a-crown."

We have, therefore, to fall back upon stocking with fry or eyed ova as a practical proposition. Unfortunately, so far as the salmon of our country are concerned, we have no available data upon which the relative values of natural and artificial methods can be assessed. We know that much wastage of ova occurs when salmon spawn, on the other hand, we know that, given a fair chance, our rivers are wonderfully productive. We likewise know that by artificial hatching we can eliminate much of the wastage of ova, but we do not know the effect of our intervention upon the vitality of the fry so reared. Will they adapt themselves to their new environment as readily and as successfully as the native fry of the streams into which they are introduced? It is almost certain they will not do so, and we are thus left to conjecture how far this process falls short of nature's results. That we are not left entirely in the dark is due to the energy and activities of the Biological Board of Canada. There was a sudden and phenomenal decline in the sockeye salmon fishery of the Fraser River, British Columbia, which attracted world-wide attention. Artificial propagation was resorted to in order to restore the river, but much criticism was made of the methods used. In one of the publications issued later by Dr. R. E. Foerster, who undertook the subsequent investigations, he says: "In 1925 the Biological Board of Canada was requested by the Fisheries Branch of the Department of Marine and Fisheries to undertake an investigation which would determine the efficiency of natural propagation and the efficiency of the various methods of artificial propagation of the various species of fish then being propagated." Now, this is precisely what we wish to know in this country, and the results now being obtained in British Columbia are awaited with the greatest of interest. It is not out of place to mention that the extent to which artificial propagation has been carried on in Canada is colossal. In 1929 the output from the Canadian hatcheries amounted to no less than 570 millions, of which 40 million eggs, and the remainder consisting of fry, were distributed. The wonder is not that the investigations should be carried out on such a big scale, but that they were not commenced prior to the erection of so many hatcheries.

It would be out of place here to describe in detail the technique of Dr. Foerster's investigations. The programme commenced with the spawning season of 1925, and will extend over a period of twelve years. A branch of the Fraser River at Cultus Lake was chosen as the site for the experiments, and here a barrier was erected in such a manner that the ascending fish and the descending migrants could be handled and counted. The method of propagation proposed was as follows :—

Natural Spawning	1925	1928	1931	1934
Distribution of Fry	1926	1929	1932	1935
Planting of Eggs .	1927	1930	1933	1936

The results obtained up to 1927 have been published by Dr. Foerster, and further results are given in a recent book, "Salmon Hatching and Salmon Migrations," by W. L. Calderwood, late Chief Inspector of Salmon Fisheries in Scotland. We find that only 1.13 per cent. of the total estimated number of eggs contained in the salmon ascending to spawn naturally, survives to descend as migrants. On the other hand, 3.96 per cent. of the ova artificially propagated descended. The apparent advantage held by the latter method is just under four to one, or, put in another way, artificial methods are four times as efficient as natural processes. Now, it must be remembered that these results apply to sockeye salmon, whose habits are totally different from Atlantic salmon, and, moreover, complete results for the spawning years 1925 and 1926 only are available. It is probable, therefore, that the results for Atlantic salmon would show a lesser advantage in favour of artificial propagation. Assuming a proportion of three to one, we have still to ascertain if it is worth while.

Possibly the most expensive item is the collection of eggs. In this country it may vary from 10/- to 30/- per thousand eggs. To this has to be added the costs of running the hatchery. Under the most favourable circumstances and with improved methods of collection it may be possible to produce and distribute eggs or fry at a cost of 10/- per thousand. Now, one thousand ova will produce thirty smolts, so that each smolt costs fourpence to produce. Again, we know from the Tay smolt-marking experiments that only 5 per cent. of the smolts, return as adult salmon. It follows, therefore, that 300 smolts, costing £5 to produce, will yield 15 adult fish. Now, if left to nature, the same number of ova would have produced one-third of the number of smolts—viz., 100, and these in turn would have yielded 5 adult salmon. The nett gain by artificial propagation is ten adult salmon, costing £5 to produce, or 10/- each. Clearly such a process would be uneconomical in a grilse river or in a river inhabited chiefly by small salmon, as the value of the fish in the market more often than not would not exceed 10/-. Moreover, a certain proportion of the stock must be permitted to escape for reproductive purposes. On the face of it, it would appear that an overwhelming case in favour of artificial propagation has not yet been established.

Careful consideration of the problem is bound to direct attention to the greater need for adequate protection of the fry, whether artificially produced or not. The Cultus Lake experiments show that the loss from the fry to the smolt stage is 94 per cent., and here at least something surely can be done to minimise this loss. If we can reduce this loss by only 6 per cent., we shall have doubled our production. A serious and sustained endeavour must be made to ascertain the various causes of loss, and if possible to eliminate or lessen them. Overcrowding of spawning grounds strikes one at once as being undesirably wasteful. It is wasteful because much of the ova laid down by the earlier fish is uprooted by later spawning fish, and it is undesirable because overcrowding leads to epidemics of disease. Further, the surviving fry encounter fierce competition for the limited food supply at their disposal, many are literally starved to death, and the survivors are undersized and ill fitted for their sojourn to the sea. The opening up of barriers and obstacles, therefore, must be one of the first improvements to be executed. Pollution in many forms is present in practically every river. Road tarring, sheep dip, washing of artificial manure bags, industrial effluents of all kinds, and inefficient sewage disposal plants, all contribute towards the decimation of young fish and the food upon which they exist. Predatory birds and fishes, and even the casual angler unversed in the differentiation of species, take their toll of parr and smolts. Further losses are caused by turbines and the abstraction of water from its natural course. Much can be done to protect our young fish, and the creation of additional breeding-grounds and the provision of insect-breeding establishments would appear to offer great scope for future development. It is to be hoped, therefore, that the authorities on this side of the Atlantic will direct their attention to the possibilities in this direction, and perhaps in time we may see our rivers restored to their pristine purity and productivity.

XIII.—*The Arctic Clay of Errol, Perthshire.*

With Plates XIII. and XVII.

By Charles F. Davidson, University College, Dundee.

(Read January 8th, 1932.)

1.—Introduction.
2.—Lithology of the Deposit.
3.—Fauna of the Clay.
4.—The Driftwood.
5.—The Erratic Boulders.
6.—The Horizon of the Arctic Clays.
7.—Bibliography and References.

INTRODUCTION.

The arctic clay described here is that situated about one hundred yards south of Inchcoonans Station, Errol. Clays of the same horizon form the surface deposits of most of the landward part of the Carse of Gowrie, and their somewhat rare exposures have formed the subject of numerous contributions to geological literature by many early workers, the publications of whom are given in the appended bibliography. Of these, the works of T. F. Jamieson *(6) and Rev. Thomas Brown (1) are outstanding, while a valuable and succinct account of the deposit, with a list of the entomostraca, is given in Brady, Crosskey, and Robertson's monograph (2). Passing references are made throughout the works of Sir Archibald Geikie (4) and Prof. James Geikie (5) on glacial geology.

An investigation last summer has produced some new faunal assemblages and facts of interest which are dealt with in the following pages.

LITHOLOGY OF THE DEPOSIT.

The deposit at present exposed shows:—

Top. (3.) 8-10 feet yellowish-brown sandy clay or silt, less compact than the underlying deposits.

(2.) 5-7 feet fine blue clay, increasing in coarseness towards the top.

(1.) 4+ feet fine red clay, base not exposed.

The bottom red clay and the blue clay gradually merge into one another, but the transition to the top yellow-brown clay is sharper, there being a more or less clear-marked boundary between beds (3.) and (2.). This sudden change in deposition associated with a marked but gradual increase in coarseness of grain from the base upwards, will be referred to later.

Bands where the clays have been blackened by the admixture of seaweeds and other organic matter are of frequent occurrence, and usually contain faunal assemblages distinct from those of the rest of the clay. Decomposed algae may occasionally be found along the bedding planes. Lenticular seams of sand are also common, especially in the lower part of the deposit. These sands are of two types, one yellowish-brown, the other black; both have a high heavy mineral content, the black sand containing as much as one-third magnetite.

Enclosed boulders are common throughout all the beds of clay, varying from the size of a pea to masses three feet in diameter. Many of these boulders are striated, and they occasionally cause a marked depression of the underlying sediment, into which they have probably been dropped by floating ice-bergs and floes. The lenticular nature of the sand-seams, and their high heavy mineral content, seems to point

* Numbers in parentheses refer to papers in bibliography.

out that they also have been dropped from melting ice in the Firth.

Extraordinary forms of sedimentation occasionally occur. Two summers ago, a portion of the pit laid down under the action of a whirlpool, about 20 yards in diameter, was discovered. Formerly, also, in some parts of the deposit, concretionary nodules were found, although they are much scarcer here than at Pitfour nearby, or at Cauldcots, Arbroath, where they occur abundantly. They are highly calcareous, and appear to have been formed by the simultaneous precipitation of lime and deposition of clay round foreign organic nuclei, now decomposed.

Fauna of the Clay.

The arctic clay of Errol possesses what may be regarded the finest fauna of any arctic clay on the East Coast. Shells are very abundant, and are all *in situ*, with their siphons uppermost, and the most delicate epidermis adhering. Unfortunately all save a very few species crumble rapidly on exposure, rendering identification difficult and sometimes impossible. A shower of rain clears the pit of all save microscopic fossils.

The complete faunal list is appended.

Mollusca.

Chlamys groenlandica Sowerby.
Musculus nigra Gray.
Musculus discors Linné var. *laevigata* Gray.
Saxicava arctica Linné.
Saxicava pholadis Linné.
Buccinum groenlandicum Chemnitz.
Astarte borealis Chemnitz var. *placenta* Morch.
Nuculana minuta Muller.
Natica pallida Broderip and Sowerby.
Thracia truncata Brown.
Portlandia arctica Gray.
Portlandia intermedia M. Sars.
Crenella faba Muller.
Nucula tenuis Montagu.
Tellina (Macoma) calcarea Chemnitz.
Yoldia norvegica Dautzenberg and Fischer.
Turritella reticulata Mighels and Adams.
Ostrea edulis Linné.
Pleurotoma sp.
Axinus sp.
Arca sp.
Mytilus sp.

Entomostraca.

Cythere viridis Muller.
C. lutea Muller.
C. convexa Baird.
C. globulifera Brady.
C. villosa G. O. Sars.
C. concinna Jones.
C. emarginata G. O. Sars.
C. mirabilis Brady.
C. Dunelmensis Norman.
C. torosa (Jones) var. *teres* B. C. and R.
cf. *C. mirabilis* Brady.
Cytheridea papillosa Bosquet.
C. punctillata Brady.
C. sorbyana Jones.
Krithe glacialis B. C. and R.
Cytherura concentrica B. C. and R.
C. gibba Muller.
Cytheropteron latissimum Norman.
C. nodosum Brady.
C. arcuatum B. C. and R.
C. inflatum B. C. and R.
C. Montrosiense B. C. and R.
Scherochilus contortus Norman.

Crustacea.

Balanus crenatus Bruguière.

Echinodermata.

Ophiolepis gracilis Allman.

Annelida.

Spirorbis sp.

Polyzoa.

Crisia eburnea Linné.

Foraminifera.

Elphidium arcticum Parker and Jones.
Polymorphina cylindroidea Roemer.
Lagena squamosa Montagu.
Miliolina seminulum Linné.

Mammalia.

Phoca vitulina Linné.

Plantae.

Algae.
Driftwood.

Notes on Mollusca.

Musculus discors Linné, var. *laevigata* Gray.

Very common. With one doubtful exception about 40 mm. long in the Kinnaird collection, the largest measured was 32 mm.

A diminution in size of this variety when traced northwards has been recorded by Jensen (13) and by Baden-Powell (7), the former reporting full-grown specimens ranging from 48 mm. at Iceland to 28 mm. at Jan Mayen. The second Fram expedition (12) has obtained specimens 17 and 19.5 mm. long from Novaya Zemlya. The Errol specimens most closely resemble in size those recorded from the east coast of Greenland.

M. discors var. *laevigata* is abundant in all the arctic provinces north of the Faroes, from which it has not been recorded. *M. discors* var. *substriata* with radial striae on the posterior area, may occur, but the tendency to decomposition on exposure renders this identification doubtful.

Musculus nigra Gray.

Very common. One fragmentary specimen attains an approximate length of 56 mm. Over two dozen have been measured from 40 to 42 mm. The species has been recorded from all arctic provinces, including the Faroes. Rare "dead" shells found in Scotland may possibly be fossil.

Chlamys groenlandica Sowerby.

Very common. This fossil has two areas of distribution, one typically arctic—Spitzbergen, East Greenland up to 65° 35′ N.L., West Greenland up to 81° 41′ N.L. (Discovery Bay), Iceland and Jan Mayen—and another in temperate waters south of the Faroes. All the northern Atlantic specimens, however, are dwarf forms rarely exceeding 10 mm., while full-grown arctic specimens vary from 22 mm. at Jan Mayen to 32.5 mm. at Spitzbergen.

The full-grown specimens in the Errol clay attain a maximum diameter of 26 mm. while specimens of 25 mm. are common. In this respect these specimens are equidimensional with some from South Greenland.

Astarte borealis Chemnitz.

Very common. Maximum dimensions: breadth 12 mm., length 38 mm., height 27 mm. Height/length = 71%. Breadth/length = 31.7%.

As the breadth/length ratio is in all shells measued under 35%, these must be referred to var. *placenta* Mörch. The height/length ratio is one of the lowest recorded.

This species has been recorded from all the intensely arctic provinces, but not by a reliable or modern authority from the Faroes (13). The most northerly specimens possess a thick frayed periostracum absent from those of the arctic clays, but the Errol shells resemble those of West Greenland in being of the highly compressed variety *placenta* Mörch. The average breadth/length ratio of the normal species, on the other hand, is 42% (Iceland).

Saxicava pholadis Linné and *S. arctica* Linné.

Very common. Both forms are present, but the elongated form *S. pholadis* is dominant. The maximum individual measured was 38 mm. in length and 25 mm. in height. The true form *arctica* is somewhat rarer, and specimens are much smaller, maximum about 24-25 mm. in length, 12-13 mm. in height. There are a few shells intermediate between the two species.

The majority of the specimens of both species are rough and thick-walled, but a large number of a smooth and thin-walled *S. pholadis* have also been met with.

Buccinum groenlandicum Chemnitz.

Very common. This species occurs very abundantly in occasional bands of silt grade, stained by organic debris in the lower clays. In those bands the faunal assemblage, distinct from that of the rest of the clay, is mainly *Buccinum groenlandicum*, *Portlandia* sp., *Crisia eburnea*, *Spirorbis* sp., and some foraminifera. The contraction of the clay on setting, however, has invariably fractured the last whorls, so that complete measurements cannot be obtained. Opercula measure up to 12 mm. x 8 mm. All specimens are very thin-shelled, and a few seem definitely referable to var. *patula* G. O. Sars.

Ostrea edulis Linné.

There is no reliable record of *Ostrea edulis* from Iceland, and the present distribution stretches from Tranen in Norway close to the arctic circle, to the Mediterranean. *Ostrea edulis* does not extend north of the arctic circle, and does not enter the Baltic.

The apparently anomalous appearance of this shell associated with intensely arctic forms is explainable by the fact that it only occurs in the coarser top beds of the clay, where it marks a return to more temperate conditions. It should be noted that oysters occur in the surface soil at this locality, either derived from overlying Carse clays, or more probably transported as fertiliser. The specimens under consideration, however, were obtained six feet under the ground in undisturbed strata. Both adult shells and fry occur.

Thracia truncata Brown.

Rather rare. Maximum length 25 mm., maximum height, 19 mm. Height/length=76%

Dimensional variation of this species with climate has not yet been adequately demonstrated. According to Baden-Powell (7), the southern limit of the true *truncata* is approximately the Lofoten Islands, the form *villosiuscula* being dominant south of this.

Tellina (Macoma) calcaria Chemnitz.

Rare. One specimen only examined. Length 23 mm., height 16 mm. Height/length=69.9%.

Portlandia intermedia M. Sars.

Rare. Young specimens only. Length 16 mm. Height 14 mm. Height/length=63.6%.

Portlandia arctica Gray.

Rare. Young specimens only. Length 16 mm. Height 10 mm. Breadth 6 mm. Height/length=62.5%. Breadth/Length=37.5%. This specimen is almost equidimensional with the smallest specimen recorded by the second "Fram" expedition to Novaya Zemlya (12.)

Natica pallida Broderip and Sowerby.

Rather rare, but occurring both as adult shells and fry. Maximum diameter 19 mm.

Yoldia norvegica Dautzenberg and H. Fischer. (=*Leda limatula* auct.)

Reported Brady, Crosskey, and Robertson.

Turritella reticulata Mighels and Adam.

Reported Brady, Crosskey, and Robertson. A fragment in Dundee Museum may be referable to this species.

A consensus of the distribution of the specifically named mollusca—with the exception of *Ostrea edulis*, which does not occur throughout the deposit—taken from various arctic memoirs (9, 10, 12, 13, 15, 17) gives the following results:—

Locality	West Greenland	Spitzbergen	East Greenland	Iceland	Faroes	East of Scotland
No. of Errol Species Living.	17	17	11—13	13 ? 14	10 ? 11	7

Number of species occurring at Errol=17.

From this it appears that the climatic equivalent is colder than Iceland and the Faroes, but warmer than East Greenland. This is approximately borne out by the dimensions of the mollusca, and all considered, it appears that the closest climatic equivalent available is West Greenland.

With the exception of *Saxicava pholadis* and perhaps *S. arctica*, the forms reported as still alive in Scotland—*Nucula tenuis*, *Nuculana minuta*, *Musculus nigra*, *Natica pallida*, and *Macoma calcarea*—are of very rare occurrence. Presumably they form the last survivals of ice age times, which are rapidly dying out. Some of the records may be due to fossil specimens.

The Entomostraca.

The list of entomostraca is abstracted from Brady, Crosskey, and Robertson's monograph (2). A few of these were not found during the present investigation, but *Cythere torosa* (Jones) var. *teres* B., C. and R., is recorded for the first time from the deposit. A species or variety undescribed in the monograph, resembling very closely *Cythere mirabilis* Brady, but differing from it in the absence of both posterior and anterior spines, has been obtained. This, however, may be simply a monstrosity.

The arctic entomostracan, *Cythere mirabilis*, which has been recorded from Spitzbergen seas, is overwhelming in its abundance.

The Foraminifera.

Elphidium arcticum and *Polymorphina cylindroidea* are extremely common, but *Lagena squamosa* and *Miliolina seminulum* very much rarer. The species of *Elphidium* and *Lagena* are all rather pauperate.

I am deeply indebted to Dr. E. Heron Allen for the identification of these *foraminifera*.

Mammalia.

Phoca vitulina Linné.

Brown (I) in 1867 recorded a find of the vertebra of the common seal *(Phoca vitulina = Calocephalus vitulinus)*. This occurrence has been verified by the discovery of a portion of the pelvic girdle. The bone is too big for the small arctic seal, *Phoca hispida*, and is presumably from a rather young specimen of *Phoca vitulina*.

The Driftwood.

Fragments from four large pieces of driftwood, up to three feet in length, which were obtained from the lower beds of the clay, were submitted to Dr. Gunnar Erdtman, of the University of Stockholm, and were identified by Prof. Lagerberg, of the Stockholm Forestry College, as oak.

The occurrence of oakwood with such a distinctly arctic assemblage of mollusca is of considerable interest, as the oak, with to-day an altitudinal limit of about 1000 feet, is by no means an arctic species, and could not have existed when, according to Lewis, the snowline lay between 1000 and 1500 feet. The wood may have been derived from some very early interglacial deposit, but in this case the probability of four specimens becoming water-logged at approximately the same locality seems to be very slight, unless they were all imprisoned in the same iceberg; and one perhaps may be tempted to postulate that in some part of the interior there flourished the first of the oaks, relics of which are so abundant in the succeeding Tay Forest Bed, which is referred by Lewis* to the Upper Forestian, and by Samuelsson† to the Lower Turbarian. On the data at present available, however, no definite conclusions can be drawn, but the occurrence of these Pleistocene oakwoods at this very low horizon must be put on record.

Robertson and Crosskey‡ have also recorded the occurrence of oak, associated with some arctic shells, in the Clyde Beds of Jordanhill, but at this locality it succeeds beds containing Mytilus edulis.

I wish to acknowledge my indebtedness to Dr. Erdtman and to Prof. Lagerberg for the identification of this species.

THE ERRATIC BOULDERS.

The great majority of the boulders enclosed in the pit are amygdaloidal and other andesites and basalts similar to those exposed in the Braes of the Carse to the north, whence they were probably derived. Local volcanic tuffs, dolerites, sandstones, and volcanic breccias are also common. Among a large variety of Highland rocks have been noted many schists, gneisses, granites, and hornfelses, with rarer diorites, epidiorites, and peridotites. It has not been found possible to trace any of these to their place of origin.

The most interesting erratic discovered was a piece of Carboniferous limestone, containing *Loxonema* sp., crinoids, and various *Producti*. It is entirely different in character from the rather shaly Dron outlier, and it apparently points to the rather unusual phenomenon of an ice-berg or tidal ice floating from the Fife coast north to the Tay estuary.

Small fragments of chalk and greensand which have been recorded from other arctic clays, occur rarely, and are either

* Scot. Geog. Mag., 1906, p. 252.

† Bull. Geol. Inst. Upsala, 1910.

‡ Trans. Glas. Geol. Soc. Vol. IV., part III.

of Danish origin or have been swept up from the bed of the North Sea. The numerous chalk flints in the Tay estuary, notably east of Tayport, may also be referrable to a hidden and unknown Cretaceous deposit there.*

The Horizon of the Arctic Clays.

The arctic clays of the Carse of Gowrie and of East Forfarshire rest uncomformably on the boulder clay, and are succeeded in the Carse by the carse clays, containing *Cardium edule*, *Scrobicularia piperata*, *Ostrea edulis*, etc.—the fauna of the modern estuarine mud-flats. Outside the estuary the arctic clays are succeeded by the gravels and sands of the 25-foot beach, with the modern coastal fauna. The thin peat layer of the Tay Forest Bed probably separates the two horizons in many areas, but I know of no locality where a *fossiliferous* arctic clay, forest bed, and carse clay may be seen in juxtaposition. It is possible that part of the earlier carse clays and the forest bed are contemporaneous.

The deposit under consideration thus belongs to the last period of glaciation, and bridges the gap between the deposition of the boulder clay and the formation of the Tay Forest Bed, the neolithic age of which is fixed by the occurrence of the Red Deer (*Cervus elephas*) in it. The forest bed formerly occurring at Arbroath Harbour, containing *Bos primigenius*, is probably of the same age.†

The overlying Carse Clays, which are therefore also of Neolithic age, and which are referred to by James Geikie (5), C. E. P. Brooks (8), and C. P. Martin (14) as clays of 45-50 foot beach age, are the estuarine equivalents of the widespread 25-foot beach. The considerable confusion which has been occasioned by this correlation seems to make it necessary to refer the Carse Clays to 25-foot beach age, as Jamieson (6) and W. B. Wright (16) have done, with the qualification that they may extend up to 40 feet above sea-level. They are of later date than the *coastal* 50-foot beach of Geikie, which is so locally developed that Wright questions its existence as a distinct strand-line.

Returning to the Perthshire arctic clays, it appears that the lowest of these forms the sea-floor of the 100-foot beach, which extends in a denuded condition round the Braes of the Carse and the Upper Old Red Sandstone outlier of Clashbennie and Errol Park, parts of which probably formed ice-capped islands in the arctic sea. No fossils, as far as I am aware, have been obtained from this beach locally, due perhaps to the density

* Cf. Dr. G. A. Cumming, Trans. Edin. Geol. Soc., xii, i, page 139.

† Specimens referred to are in Perth and Dundee Museums.

of vegetation and the depth of ordinary soil and humus. It is not improbable that a depression greater than 100 feet occurred, giving rise to some high-level clays elsewhere, but this beach marks the first period of continued stability.

The increase in coarseness of the clay from the base upwards seems to point to deposition in water gradually becoming shallower, and the incoming of *Ostrea edulis* towards the top indicates conditions becoming distinctly less arctic. It may be that beds considerably warmer in fauna formerly overlying those now exposed have been denuded.

We may thus visualize the following conditions:—At 100-foot beach times, the deposit of clay, now about forty feet above sea-level, lay ten fathoms deep. A Piedmont glacier which still covered parts, at least, of the interior, and a seasonal ice-foot which every winter formed round the encircling coast, provided, on the return of summer, icebergs which floated freely about the Firth, and which on melting deposited their adhering boulders and beds of gravel in the underlying silt. Deposition of a fine rock-flour from glacial denudation processes in the interior continued in the estuary, the sea-level of which maintained the 100-foot horizon, with perhaps very gradual emergence of the land. Between beds (3.) and (2.), however, there occurred a more sudden isostatic uplift, an adjustment which may perhaps be correlated with the final recession of the sea from the 100-foot beach. Following this, deposition under conditions gradually becoming warmer continued, and the extent of the Tay estuary diminished with the gradual emergence of the former 100-foot sea-floor as land—land on the low and swampy parts of which now flourished the Tay Forest Bed. The latter contains associations of plants which are *in situ*, and which are water-drifted, and seems to have formed part of the mud-flats, cut off by a sandspit or similar barrier. Two forest beds, separated by carse clays, have been recorded from excavations at Dundee Post Office (11).

Two further, but minor, isostatic adjustments—one positive and one negative—concluded the series of oscillations to give rise to the Carse Clays, gravels, and sands of the 25-foot beach.

The difference in character between the Arctic Shell Clay of Errol and those of other parts of Scotland was first recognised by Crosskey (3), and later elaborated by Brady, Crosskey, and Robertson (2). In fauna, this deposit is almost identical with the clays of Elie and Drylees, Montrose, but when compared with the Clyde Beds there are distinct differences. *Thracia truncata*, *Portlandia arctica*, *Portlandia intermedia*, *Yoldia norvegica*, and *Turritella reticulata* have not to my knowledge been recorded from similar beds on the West Coast. *Musculus nigra*, *Musculus discors* var. *laevigata*, and *Nuculana minuta* are extremely rare in the west, generally being recorded as fry only, while the forms *Astarte borealis* and *Buccinum groenlandicum* are also of rather exceptional occurrence.

A rather peculiar deposit at Tangy Glen, near Campbeltown, which *underlies* the boulder clay, has furnished a fragmentary valve of *Chlamys groenlandica*, the only one recorded from the West; and this deposit also resembles the East Coast beds in containing the arctic entomostraca *Cytheropteron Montrosiense* and *Cytheridea sorbyana*, which with the exception of one other carapace of *Cytheropteron Montrosiense* (at Govan) are entirely East Coast forms. The apparently anomalous position of the Tangy Glen deposit underneath the boulder clay may be in some way connected with this variation in fauna, as it may have been transported by the method put forward by Debenham,* or in some other manner.

The dominant Errol entomostracan, *Cythere mirabilis*, which occurs in hundreds, and the rarer *Krithe glacialis*, have not yet been recorded from the West Coast.

The climatic equivalent of the Clyde Beds appears to vary from the Faroes to South Iceland, and that of the Errol beds has been shown to be West Greenland. It may be thought, therefore, that the east coast deposits are of earlier date than the corresponding fossiliferous clays on the west, but the explanation first given by Brady, Crosskey, and Robertson, that the colder nature of the deposits may be due to an arctic current, similar to that which now sweeps over the Dogger Bank, but colder, may adequately account for the temperature difference. At the same time it is very peculiar that the clays of Banffshire and Aberdeenshire, as typified by those at Gamrie, Annochie, and King Edward, are much more akin to the Clyde Beds than to the Errol clays.

Close observation shows, however, that two out of the three best-known intensely arctic clays—Errol and Montrose—have been formed under estuarine conditions, in which the ice may have persisted long after the open coast had become tenanted by a warmer fauna. The anomalous case of the Elie clay, which lies to-day at or below sea-level, may be due to persistence of colder conditions in the deeper parts of the North Sea.

Beyond the acknowledgements in the text, I am deeply grateful to Dr A. C. Stephen, of the Royal Scottish Museum, for the specific determination of some mollusca, and to Mr D. F. W. Baden-Powell, of Oxford University Museum, for much helpful discussion; to Mr A. Webster, of the Albert Institute, Dundee, for the loan of the late Lord Kinnaird's specimens, and to Mr J. Ritchie for the loan of specimens in this society's custody and for the preparation of several plates;

* Quart. Journ. Geol. Soc., 1919.

and especially to Mr D. E. Innes, Dr F. Walker, and Dr J. F. Scott for their never-failing interest in matters of local geology.

The mollusca from the deposit just considered are of a very fragile mature, and Mr Ritchie suggested to me that he should treat them with Vinyl Acetate, a process which he has carried out with very satisfactory results. The fossils, which must be perfectly dry, are dipped for a moment in a 3 per cent. solution in acetone, and then exposed to the air. The solution rapidly penetrates through the porous shell, and on evaporation of the acetone, the Vinyl Acetrate immediately polymerises to a protective resin, formed rather inside the pores of the specimen than as an outside coating, as was the case with former processes. After treatment the fossils may be handled without damage.

The process appears to be much superior to former methods involving the use of collodion or cellulose preparations, especially if the specimens are intended for photographic reproduction. In no way has it been found to discolour or dissolve the fossils.

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XIV.—*Notes on Two New Perthshire Algae.*

By J. Ritchie.

(Read December 12th, 1930.)

A small Alga was found by Mr Menzies on Buckie Braes. It was adhering to the rock surface, and seemed to be plentiful. I sent it to Dr F. G. Fritsch for identification, and he reported it to be *Dichothrix compacta* (Ag.) Born et Flah.

I also found the same Alga, in August, adhering to the rocks in one of the small streams on Schiehallion, at about 2400 feet up.

In May, 1931, Mr Berry was engaged marking Salmon Smolts on the Tay opposite the mouth of the River Earn. One evening when I was present the net used in the operations was found packed with an Alga which was later identified as *Sacheria fluviatilis*. Mr Berry told me it was found in the net almost every time a haul was made.

PLATE XIII.

Inchoonans Clay Pit, Errol, showing (1) Upper layer; (2) middle layer; (3) lower layer of different clays.

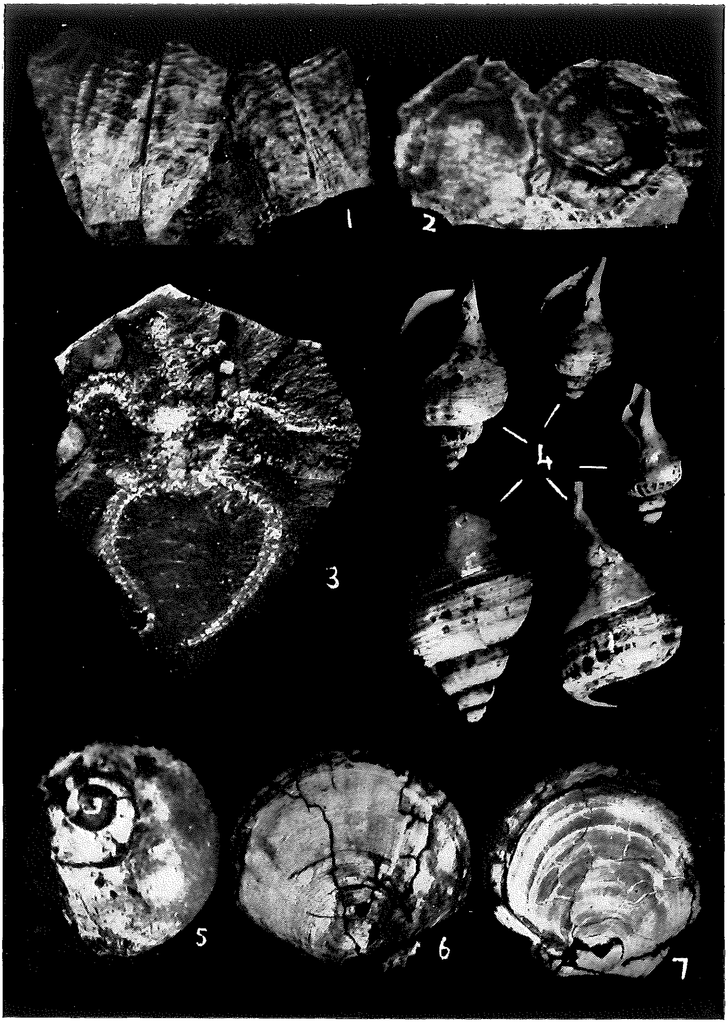


PLATE XIV.

1. Bolanus crenatus, side view.
2. Do., section view.
3. Ophiolepis gracilis.
4. Buccinum groenlandicum.
5. Natica pallida.
6. Chlamys groenlandica, exterior surface,
7. Do., interior surface.

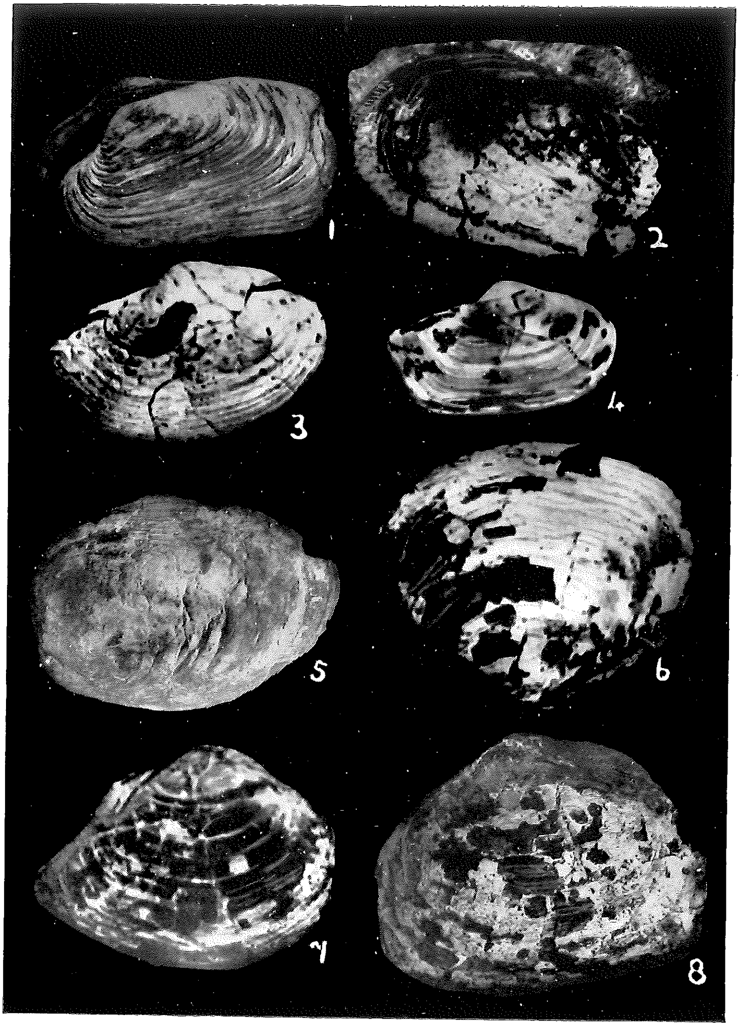


PLATE XV.

1. Saxicava pholadis.
2. Musculus discors, var. lævigata.
3. Portlandia intermedia.
4. Portlandia arctica.
5. Musculus discors.
6. Thracia truncata.
7. Tellina (Macoma) calcarea.
8. Astarte borealis, var. placenta.

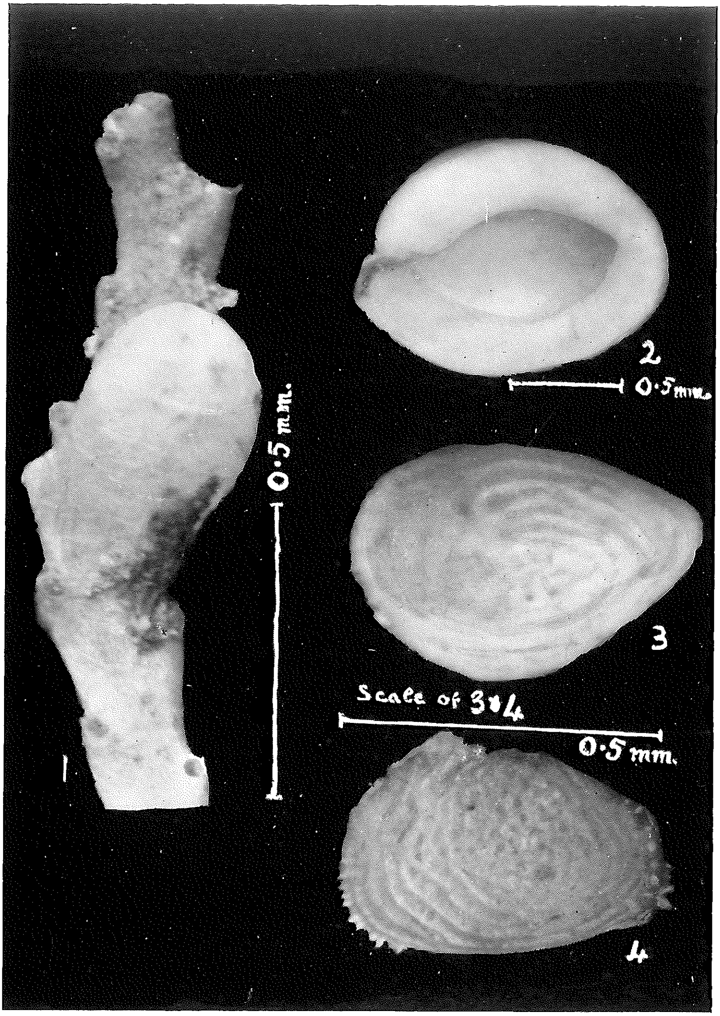


Plate XVI.

1. Crisia eburnea.
2. Miliolina seminulum.
3. Cythere cf. mirabilis.
4. Cythere mirabilis.

PLATE XVII.

Part of pelvic girdle of Phoca vitulina L., showing outer and inner surfaces.

XV.—*The Story of Sea Trout.*

A Summary.

By W. J. M. MENZIES.

(read December 11th).

Trout, ranging in Europe from the White Sea down to the Mediterranean, and those which have extended eastwards in to the Black and Caspian Seas, as well as the few colonies of brown trout which exist in the North of Africa, all belong to one species. The original stock was formed by a migratory fish inhabiting the colder seas, which extended during the time of the southerly limit of ice down to the Mediterranean. As the ice retreated the sea temperature rose and became less to the liking of the sea trout and their southern limit also retreated northwards. The sea going habits of some were restricted and finally estuarine and fresh water colonies were established. It is these non-migratory colonies of brown trout which now populate the fresh waters of Europe, and it is the original migratory stock which forms the sea trout of Great Britain and the other European countries on the west side of the Continent. The Southern limit of the sea trout at present is the north of Spain and Portugal, and from there it is found along all the coasts and in most of the rivers of Europe to the North Cape, and as far at least as the White Sea. The sea trout is also found in the Faroes and in Iceland, but not on the other side of the Atlantic, where the so-called sea trout of Newfoundland is really a migratory char.

Sea trout spawn in the autumn in the burns and smaller tributaries of the rivers which they frequent and some two or three weeks before the salmon in the same district also spawn. The alevins are hatched in spring, the time required for the development of the egg being dependent upon the water temperature. When first hatched the alevins are curiously helpless creatures, very much weighed down by a large yolk sack attached to the under side of their bodies, on the contents of which they exist for the first three or four weeks of their lives. As the available yolk diminishes in quantity so do they begin to feed and about six weeks after hatching they are entirely dependent upon the food which they may find. They then to all appearances become minute, but perfect, fish well able to look after themselves and move freely about in search of nourishment. One will often see them lying up two or three, or perhaps only one, behind a stone in the river and from there they will make little darting movements, first in one direction and then another, in an apparently aimless way. They are then, however, chasing the minute food on which they exist and which they see being brought down past their hiding place by the stream. At this stage they are known as fry, and later in the summer become parr, when they are to all appearances typical little trout with a number of broad vertical, not very well defined, marks down each side, which are known as parr marks and which are carried by salmon parr also. Normally, in Scotland, at the end of their second or third year, occasionally at the end of their fourth or fifth, or very occasionally even at their sixth year they undergo a physiological change. A silvery sheen begins to hide their former brown trout-like appearance and they commence to move downstream. By the time they have reached the top of the tidal waters they are quite silvery. All signs of the parr marks have disappeared and they have become smolts. The change in their appearance, however, is only surface deep and is caused by the deposit of material known as guanin in the skin which reflects the light, and if this be removed the typical brown trout marks and spots will be found still to exist underneath.

Some smolts hang about the estuary for a considerable time, move up and down with the tide and feed on such of the smaller forms of estuarial life as are suited to their size. Others, however, take a more direct way to a fully marine existence and leave the river for the open sea. Where they may go in the sea is not known, but their wanderings are considerably greater than was at one time thought to be possible. Many, if not most, however, return to the river of their birth as whitling (known also as herling, finnock, lammas trout, etc., in various districts) during July or August of the year in which they went down as smolts. They then weigh from 5 or 6 ozs. up to as much as $\frac{3}{4}$ lb., the general average perhaps being about 7 or 8 ozs., but the size rapidly increases and by the end of September many whitling may weigh as much as 1 lb., and an occasional specimen even $1\frac{1}{4}$ lb., but the general average of those which have been found up to this date is about $\frac{3}{4}$ lb.

The great majority of whitling do not go far up the rivers but remain either in the tidal waters or a comparatively short distance above these reaches. Some, however, penetrate a certain distance inland, and may go as far, for instance, as Callander in the Teith (20 miles from the tide) and they have also been seen nearly 25 miles up the Thurso river. Comparatively few are preparing to spawn and the proportion, which varies from river to river, is not accurately known. It is probable, however, that in general not more that about 10% spawn during this winter of their lives; the remainder either hang about the estuary or fresh water, or make a number of minor migrations from one area to the other, according to the temperature and height of the river. A certain number also have continued feeding in the sea longer than the main body, and these also come in to fresh water at various times during the winter months. None, however, feed to any marked extent at this time and all lose condition, even when they continue to live actually in the sea. Those in fresh water that do not spawn may even become very black and thin. Whitling begin to return to the sea in the early part of the year and by the end of April or early in May all, along with the whitling and adult kelts, are back in salt water.

The adult trout in the second year of their lives in the sea, form the bulk of the stock of sea trout available for nets and rods on the east coast of Scotland, and normally begin to come in in May. The height of the run is reached in June or early in July. The majority of these, as has been shown, are fish which have never spawned; with them is mixed a certain number of older fish, a few of which may be in their third summer and also have never spawned, and a much larger proportion in their third, or subsequent sea summer which have spawned on one, or more, occasions. On the east coast of Scotland, however, it is very rare to find a sea trout which has spawned more than once or twice during its life, although on the west coast the frequency of spawning is much greater and an individual fish may have as many as eight or nine, or exceptionally even eleven, spawning marks on its scales.

In certain districts such, for instance, as the Tweed, Orkney and Loch Lomond, growth is very much more rapid than in the majority of rivers and the conventional sea trout in its second sea summer instead of weighing $1\frac{1}{4}$ lb. to $1\frac{3}{4}$ lb. may be even as much as $2\frac{1}{2}$ lb. to 3 lb. or even 4 lbs.

In certain districts, such for instance as Orkney and South Uist, a spring run of sea trout is alleged to exist, but this is not the case. The majority of the larger fish in these waters in the early part of the year are kelts, but among them are a certain number of clean fish of all sizes up to as much, it may be, as 8 or 10 lbs. which have come in from the sea during the winter months and are there resting in the same way as the younger and smaller whitling. There is no evidence that clean fish actually come in during, or after, January, and it would seem that all the trout caught in the spring have been in fresh water for some time. There is, however, a spring run in the Tweed which starts as early as December, and in which the trout may average from 4 to 5 lb. in weight each. A spring run of a somewhat later date also exists in the Ailort in Inverness-shire which, however, does not really commence until March. Normally, however, throughout Scotland there is no spring run of sea trout of any dimensions, although a few clean fish may be caught from time to time throughout all the early months of the year.

A sea trout alleged to be 31 lb. in weight was taken in the Shetland Islands about 20 years ago, but the heaviest properly authenticated specimen is one of 29 lbs. caught in the Loch of Stenness in Orkney. A trout of 19 lbs. has been caught in the Tay; another of 17 lbs. in the Lossie; two of 16 lbs, both by rod and line, and the heaviest caught by that method in this country, in the Ailort; and many others in different districts weighing from 10 to 15 lbs. have been taken.

Marking has shown that sea trout travel much greater distances in the sea than until recently was thought to be probable. Sea trout marked in the Tweed have been caught on the coast of Denmark and Holland and off the Norfolk coast in England. Many other specimens from other east coast rivers have been known to travel as far as 150 miles from their native river. The normal rate of journey is probably about 8 miles per day when the fish is actually making a passage, but considerably greater speeds have been recorded for comparatively short distances.

XVI.—*The Geology of Moncreiffe Hill.**

By CHARLES F. DAVIDSON.

(Read January 8th, 1932).

ABSTRACT.

The volcanic rocks of the Moncreiffe Hill area, south-east of the city of Perth, have been investigated preliminary to more detailed studies on the Sidlaw Hills. They are dominantly microporphyritic olivine-enstatite-basalts, showing microphenocrysts of olivine and enstatite, now serpentinised, in a groundmass of felspar (medium labradorite) and granulitic augites. Several flows of a similar type, but containing large phenocrysts of labradorite felspar, occur throughout, particularly towards the base of the sequence. Segregation veins in the olivine-enstatite-basalts of Friarton Quarry show a particularly interesting mineral assemblage, principally comprising alkali-felspar, analcite, and

* *vide*—C. F. Davidson, "The Geology of Moncreiffe Hill, Perthshire." Geological Magazine, Vol. LXX., October, 1932, pages 452-465.

hornblende. Such segregations are important in throwing light on the trend of differentiation of an Old Red Sandstone basaltic magma.

The sediments of the area comprise sandstones, shales, volcanic conglomerates, and ashes, all of Lower Old Red Sandstone age. Their most remarkable feature is the occurrence in them of great numbers of acid pebbles, including types apparently unrepresented in the Sidlaws sequence, and the relations of the rocks to those described from northern Forfarshire and Kincardineshire are thus ascertainable.

A description was also given of the later dykes of east-west trend which pierce the lava-flows.

XVII.—*Specific and Sub-Specific Variation in British Geese.*

By JOHN BERRY, B.A.

(taken as read 8/1/32).

The Tay Estuary is a sort of ' Clapham Junction ' for migrating water-fowl and the identification of species has always been one of my chief joys in wild-fowling, but it was not until 1926 that I became absorbed in the study of wild-geese more than in almost any other branch of Natural History.

In September of that year I shot a Brent Goose near Tayport, and in looking up the dates of arrival of these birds in this country, for September struck me as unusually early, I was amazed by the uncertainty and even flat contradiction of all the writers I consulted.

To take but one example : in the " Scottish Naturalist " for 1917, quoting from the " B.O.U. List of British Birds," the Brent Goose is said to be a Winter migrant " numerous in the Shetlands," but a few lines later we read that : "other authorities state that the Brent goose is scarce in Shetland." I next learnt from one author that there were three distinct species of Brent geese, while the next whom I consulted informed me that there was only one.

I shall have something more to say about the Brent geese later, but for the moment suffice it to say that, compared with the confusion which, before 1926, existed over the different subspecies of Canada geese, and still does exist over the various races of Bean-geese, the Brent question might have been considered all perfectly settled.

One may well ask how it is that geese which are amongst the largest, most numerous, and most widely distributed of birds, and which are, moreover, of no small economic importance, forming, as they do, the staple article of diet of several races of human beings in both hemispheres, have so long escaped the exactitude of modern systematic classification, a classification which has rendered the satisfactory identification of the minutest British butterfly a comparative certainty.

The causes which contributed to what Dr. Sergius Alpheraky called "the confusions of the goose-question," are, I think, manifold. In the first place geese are so large that they have been 'over-looked' so to speak, ornithologists have assumed that all the books contained as to their classification was proven and unquestionable; well might some fact concerning the St. Kilda wren have been over-looked, but that there could be any question as to the identification of birds weighing anything up to 15 pounds, and even over, which occur in half the counties in Britain in hundreds every year—the idea does seem utterly ridiculous!

But, when, at the beginning of this century, the ornithologists of Russia, led by such great men as Dr. Peter Sushkin and Dr. S. A. Buturlin, began, with Gallilean pertinacity, to demand the why and the wherefore of modern anserine systemisation, men were compelled to admit that many of the points for classification were far from satisfactory.

For a week or two every year, when they moult, geese are absolutely incapable of flight, and at this time both old and young birds must get as far as possible from all their foes, and man in particular. So for this and other reasons they migrate to the most desolate lands, and even at the present day the life-histories of many geese are, for six months every year, a total blank.

Even when in densely populated districts where a ceaseless war is waged against them, the percentage of casualties is very small. It is authoritatively reported that out of one flock eighty-four geese were killed with five shots, but I can assure you that, to put it mildly, such a ghastly massacre is uncommon.

Then for every goose which receives the attention of a competent ornithologist, a far larger number are never examined at all. For the average wild-fowler the classification of 'Grey' or 'Black' is quite sufficient, and as most geese are shot either in the grey dawn or at dusk, and are at once shoved into a game-bag lest their corpses scare others, unless their characters are exceptionally noticeable, they will escape comment.

Geese enjoy amazing longevity, a Canada goose for example having been known to live for over a hundred years. The adult plumage is seldom, if ever, assumed in less than four years, and in a minor degree goes on altering thoughout life, quite apart from seasonal changes.

In dealing with the geese of the Arctic, as opposed to those of the Antarctic regions, we are left without one of the greatest aids to classification, in spite of its development in most of the Northern ducks—sexual dimorphism.

The drakes of the Falcated teal and gadwall are totally unlike each other, and yet how many average wild-fowlers could tell the ducks apart? The ducks of the European and American teal are indistinguishable to any except possibly a few experts, yet the drakes, if in mature plumage, can easily be identified; and there are endless even better examples. I want to stress this point, because if we are going to differentiate the geese at all satisfactorily, we must be prepared to make use of details which in other classes of animals would appear entirely trivial.

There is one more cause of error I would like to mention before I go on to a consideration of the geese in detail, and that is the confusion of nomenclature and terminology. Although in this country the position is not so hopeless as in America, where almost any goose with a dark body is called a 'Brant,' even including the Blue Snow-Goose, with a white head and neck; still, nine out of ten ornithologists in this country will call anything with orange legs and a black 'nail' on the bill a 'Bean Goose,' although S. Alpheraky in his book: "The Geese of Europe and Asia," now the standard work on Palaearctic geese, divides the bean-geese into four species of which two species, comprising six sub-species, would all be classified in this country as a 'Bean' goose.

In describing the colours of the soft parts, a certain amount of complication is caused by the description by one author as 'yellow' what another would describe as 'orange,' and vice-versa. The colours themselves change very rapidly after death, and the bill of a pink-footed goose will change from bright pink to dark bluish-purple in as little as three quarters of an hour.

Variations—Specific and Individual.

I now want to deal with the variations of the geese in some detail, especially with regard to the comparison of specific with individual varieties. I think the simplest plan would be to deal with each type of character separately, treating the geese as a whole for purposes of demonstration. I have already mentioned the great variety of plumages we can expect to meet with in each species of goose, and at first sight the task of getting to know all these seems insurmountable; but we have one very cheering fact, and that is that geese are subject to abnormalities perhaps less than any other animal. Writing in the "Scottish Naturalist" for 1926, Mr. Hugh Gladstone, in describing the first known albino of the Bernicle goose, comments upon the extreme rarity of abnormal geese and gives a whole page of authorities and owners of private and public museums who support the late Dr. Lehn Schiöler of Denmark, when he states that he has never seen a wild-goose which was not of normal plumage. Even albinistic tendencies which are among the commonest forms of abnormalities in birds, are extremely rare in geese; Mr. Gladstone, in the paper above referred to, has only been able to hear of fourteen examples in the whole world, and when one thinks of the thousands of skins in the collections to the curators of which he wrote, this number becomes almost negligible.

Mr. J. G. Millais, in his three magnificent volumes on the ducks of this country, gave plates showing almost every phase of plumage through which each bird may pass; if and when we can do the same for the geese, the worries of their identification will have largely vanished.

The first and most obvious point when examining a goose is its size; this varies enormously, not only between species, but also with individuals in the same flock. If average size is to be of any use in the identification of a species, we must settle three other questions: first, are there any other differences correlated with the dimensional variations? secondly, are the variations connected by a series either regular or irregular, or do the types form two or more separate groups? and thirdly, is there any geographic separation to account for different races?

The first example I want to take is the Greylag goose, which has a breeding range from Iceland in the West, to Kamchatka in the East, and from the Arctic circle down to Spain, Turkistan, and Iraq.

The Asiatic specimens of this bird are by some given specific distinction under the name of 'Anser rubirostris,' the differences being in size, colour of the bill, and a darker plumage in Eastern birds. It was said that Asiatic Greylags weighed up to 11 pounds; all I can say is that in West Europe they are said to reach the colossal weight of 16½ pounds, and the examination of tedious columns of weights convinces me that there is no geographical line which separates any of these alleged variations, with the possible exception of the bill colouration.

But the best example of size variation is in the Snow-geese of North America. The Blue Snow-goose (Chen caerulescens), we can dismiss for the moment as the plumage is totally different from that of the others; but we are left with three birds, the Greater Snow, the Lesser Snow, and Ross's Snow, in all of which the plumage is white with black tips to the wings.

The sizes of these birds falls into three main groups, and although there is a certain amount of over-lapping, the averages are quite distinct. The Greater and Lesser snow-geese are almost exactly similar in colouring, but geographically they are widely separated, for the Greater predominates on the East coast, and the Lesser on the West.

Although I cannot see the justification for giving these two forms specific distinction, I think ornithologists may be justified in considering the greater form a sub-specific variety, under the name 'Chen Hyperboreus Nivalis.'

Ross's goose is very much smaller, and the bill is different, for it lacks the black edges which gives the characteristic sneering expression to the other snow-geese, and for this reason in particular it has been separated into a genus of its own to which has been given the name 'Hexanthemops'; somewhat unnecessarily I think. The breeding ground of this goose is still absolutely unknown.

The White-fronted geese have been divided into as many as five separate species by some authors, the basis for classification being chiefly size.

Personally, I think that unless there is very strong geographical evidence in support of a species or sub-species, size alone ought never to be made of specific importance. Of course it is all a matter of degree. Mr. J. H. Gurney, writing in the "Ibis" for 1902, says: "So long as the slightest difference in colour, even to the colour of an eye-lid, can be found, combined with some difference of habitat, surely such birds ought to be kept asunder." In the same article he gives as the identification characteristics of *Anser gambeli*, the American White-front, "its comparatively larger beak and darker under-parts." The method of telling the age of all geese of the typical genus 'Anser' is that the bill becomes heavier through life, and the breast, which is devoid of black feathers in youth, becomes more and more spotted in the greylag and barred in the white-fronts, until I have seen British shot examples of both species with the underparts almost completely black.

Suppose we had two resting grounds for White-fronted geese on migration, one on their Autumn journey and one on the Spring route, in Autumn the young birds are always far easier to get than the wary old ones, consequently geese shot on the Autumn migration would tend to give lower weights, smaller bills, and the majority with less or no black on the breasts. In Spring the geese are equally wary, and other things being equal, when a flock comes over one tends to pick the leading birds if all are within shot; so fewer geese would be shot, but they would average larger birds and more would have the black breasts of the adults; at least that has been my own experience.

I do not suggest that White-fronted geese migrate South through Europe, spend Christmas in mid-Atlantic, and go home via New York, but I do suggest that the mode and place of collecting may greatly affect the age of the average goose killed. It is reasonably certain that the White-fronted geese which breed in Greenland and cross Iceland regularly on migration must be making for the British Isles; and since the available data of average weights seems to show a more marked congruity between specimens frim Ireland and the Western Isles, and from the Eastern States of America, than is shown between Western and Eastern British birds (the latter resembling continental specimens from Holland, etc.), it seems fair to assume that in Britain we get two geographical races, one from Greenland and the other via Scandinavia. The same progressive variation is reported from Eastern and Western America, and the contrast between specimens from Western America and Continental Europe would certainly suggest strong grounds for at least sub-specific separation, were it not for the intermediate Greenland birds; whether their existence should lead to the recognition of three sub-species, or none, is a point of considerable controversy.

The case of the Lesser white-front (*Anser erythropus*), is quite different; not only is it very much smaller than *Anser albifrons.* but the plumage is quite distinct at all ages. I have examined living specimens of these birds side by side, and the plumage differences were as marked as the difference in size.

The Lesser white-front is far darker on the back and neck than the greater, and the white edging to the bill which in the greater rarely, if ever, reaches back to the line joining the anterior angles of the eyes, in the lesser is more in the form of a strip, reaching from the bill to well behind that line. The live birds I saw could be distinguished some way off by the fact that in the Lesser white-front the (wing) primaries extended considerably beyond the tail, while in the greater they were about the same length as the tail.

At all ages of the Lesser white-front the ceroma (or eyelids) are yellow and swollen looking, forming a complete ring round the eyes. In the greater, the ceroma is never either yellow or orange, it may be grey or brownish, but never resembles that of the Lesser bird; at least these facts have not been known to vary as far as present experience can show.

As an example of what confusion of nomenclature can do, I might mention in passing that, because one author described the bill of the White-front as 'orange-yellow' in his work, that description got into all the hand-books, and when the famous naturalist Buturlin discovered that all the White-fronted geese he shot had shell-pink bills, he described them as a new species under the name *Anser rhodorhynchus*, and it was not until a considerable time later that it was pointed out that *Anser rhodorhynchus* turned into *Anser albifrons* with the yellow bill some months after death!

Plumage.

I have tried, in talking of the size of geese, to show that, although that is important, still the most important point is the plumage. Not only does the plumage tell us most about the age, sex, and geographical race of a goose, but it is almost the *sine qua non* of specific, or even sub-specific distinction.

To begin with, almost too much importance was put upon the plumage, every new phase was put down as a new species, an *Anser* " *somethingelsicus* " ' was described almost every other day.

The ringing of wild-geese is a very modern development, and although recently a Canadian ornithologist ringed over three hundred geese in one day, still his experiments are almost unique. However, a most important development came towards the end of last century when aviaries, notably at Woburn Abbey, and at Lilford, began to breed wild-geese in captivity, and thus gave an opportunity for studying plumage variation at close quarters.

The large scale breeding of geese in captivity is, I think, the best way to learn about them, but, unfortunately, not only are wild-geese extremely costly to buy, but getting some of them to breed is next to impossible. I asked one successful breeder for hints, and he had only one : " Get your geese as young as possible, and keep them from five to fifty years in as natural conditions as you can, and you **may** do it ! " ; but one of the commonest geese, the Brent, has still, as far as I know, refused even to lay an egg in captivity.

But to get back to plumages ; the results of these breeding experiments meant that species after species was scrapped as they were found to be but transition plumages of another well-known form. The pendulum swung to the other extreme, and, to quote an example, the Blue goose of America (*Chen caerulescens*), was even in the last decade regarded as a colour phase of the Lesser Snow goose (*Chen hyperboreus*).

Their claim to specific distinction was championed by Mr. J. Dewey-Soper, quite one of the most indefatigable ornithologists of whom I have ever heard. It was shown that this so-called rare plumage-phase occurred in enormous flocks on the Luisiana Marshes, but the sceptics demanded to know of its breeding ground, and off went Mr. Soper on the quest.

That was in 1923 ; in the Autumn of 1930 came his account of the discovery of Blue Goose Plain, where the Blue goose nests in thousands in Baffin Land. Mr. Soper had travelled 30,300 miles, but the Blue Goose is now recognised as a separate species.

In this country one of the chief plumage puzzles is provided by the Brent geese, which are probably the most abundant species in the world, occurring in countless thousands on coasts all around the Northern Hemisphere.

Without a series of skins from its breeding ranges, it is impossible satisfactorily to define the geographical races of this, or any other migratory bird, but, that at least three well-marked races of the Brent exist, I am personally thoroughly persuaded.

The first type is clearly marked and uncontroversial; it is an American, or rather Pacific bird known as *Branta bernicla nigricans*, or simply *Branta nigricans*. It is much darker than our Brent, and has a white ring round the neck; it breeds from the Lena River to Western Arctic America.

In America only the Black Brant, as they call it, is found on the Western seaboard, and only Brent with white under-parts on the East, this form being generally known as *Glaucogaster*, or *Hrotah*, but in this country the "Brent Question" is one of the most controversial points in ornithology.

In the "Scottish Naturalist" of 1917, the Misses Baxter and Rintoul, who have done so much for Scottish ornithology, asked for information regarding the occurrence of the light breasted and typical Brent with a dark breast in Scotland. This elicited a strong letter from Mr. Abel-Chapman, in which he affirmed that no two such forms existed, but that there was a complete series of shades from dark to light. Hard upon this came a practical statement of the case from Commander J. G. Millais, one of the greatest wild-fowlers in the country. He pointed out that although Mr. Abel-Chapman might be right in saying that flocks of Brent in England contained as many light birds as dark, the case was quite different in Scotland, where North of the Tay Brent were "invariably" light-breasted, on the Tay usually dark-breasted, and in France and Holland dark only.

By this time the Brent business was well started, and when ornithologists gave up fighting in the Great War, they came home and started harder than ever over the Brent.

Far the best article, in my opinion, appeared in "British Birds" for 1924-25 by the Rev. F. C. R. Jourdain, who summarised our knowledge of the bird up to that date, without being at all dogmatic over the vexed question of the number of species, sub-species, geographical races, or whatever people like to call them.

Briefly the facts are these; all the Brent breeding in Arctic North America, Greenland, and as far as Spitzbergen, are light-breasted. All the birds breeding in Western Siberia are black-breasted; on the Island of Kolguev both forms over-lap. If we draw a line from Kolguev to the Wash, or England generally, we divide the two forms fairly sharply, any intermediates being accounted for by inter-breeding on Kolguev; but about this much more information is required.

Brent make terrific migration flights, one shot at the Holy Island had in its crop a shell known only from the Barents Sea, whence the bird had evidently come almost 'non-stop,' so very little evidence is available about their route.

There can, I think, be only two explanations; either there is one bird exhibiting dimorphism as we have it in a butterfly of the genus Lycaena, in which the males are brown, blue, and/or brown and blue; or else we have a parallel case of two species like the carrion and grey crows which are divided by a line from the River Yenisei to Scotland. In Sweden I saw only grey crows, in South Germany I saw only black, here they both occur and produce every phase of intermediate plumage by inter-breeding. Personally, I cannot see what the difficulty about the two geographical races is, if we are allowed two distinct species for *Corvus corone* and *Corvus cornix*, why not also for *Branta bernicla* and *Branta hrotah* ?

Soft Parts.

There is one last point of variation about which I should like to say something before I stop, and that is the colouring of the soft parts. I have already alluded to the importance of the eye-lids in dealing with the white-fronted geese, and in all the grey geese the importance of the colouring of the bill and legs is also very great.

The first point, in every sense of the word, is the nail, or point of the bill, the colour of which was, by Dr. Buturlin, considered of sufficient importance to justify the separation of the grey geese into two genera, the first being characterised by a white nail, such as is possessed by the greylag for example, and the second having a black nail, as in the pink-footed goose to which he gave the generic name, *Melanonyx*.

At first I was inclined to agree with him, but I now no longer do so as I do not consider the arguments in his favour are sufficiently strong, although they seem every bit as sound as those upon which Ross's Snow-goose is separated generically from the other Snow-geese. The colour of the nail is certainly very reliable, but several exceptions have come within my notice. My father shot a pink-foot with a white nail, and in the Royal Scottish Museum is a bean-goose with one which is largely white. Mr. Laidlay has, or had, at Lindores a greylag with a black nail, all the rest of the brood being normal, and when shooting at Loch Leven I got a right and left of white-fronted geese of which the nails were again irregular, as is frequently the case with young birds of this species.

A point in which I am considerably interested is the number of times the length of the whole bill is that of the nail. So far I have not enough data, but it looks as though the ratio of nail to bill stays constant for each species, as was, I find, suggested by Naumann as long ago as 1853.

In spite of the rapidity with which they change after death, the colours of the bill and legs afford a most important guide to the species of a goose, so long as they are noted as soon as possible after death, or best of all, while the bird is still alive.

For a long time there was a discussion as to whether the colour or length of the bill was the more important. The question had a concrete example in a goose with a bill as large as that of a Bean-goose, that is considerably larger than that of most pink-footed, but in which the colour of the bill and legs was pink or crimson, quite different to the orange-yellow of the Bean-goose; and for a time the matter was shelved, the pink-billed Bean-goose being explained in a most unsatisfactory manner by saying that it was a hybrid.

In "The Ibis" for 1897, however, Dr. Peter Sushkin described eight specimens of the supposed hybrid which he had obtained in the Ufa Government of Russia, where he said these birds occurred in large numbers; but his claim for the specific distinction of this bird under the name of *Anser Neglectus* was at that time rejected.

Although Dwight attached great importance to the colouring of the soft parts in the classification of the gulls, I do not think that that alone should constitute specific distinction, and personally I had always regarded Sushkin's Goose as a variety of the Bean-goose until a Cambridge friend, Mr. N. Volkov, himself a personal friend of Dr. Buturlin, assured me that the plumage of this species was quite unlike that of the Bean-goose; finally, thanks to the kindness of Dr. Hartert, the skins in the Rothschild collection at Tring were put at my disposal, and I was able to satisfy myself of its claim.

It was not until 1930, however, that this species received complete and unquestioned recognition, largely due to the excellent paper in "Aquilla' 'by J. Schenk, followed by others, noticeably one in the "Ibis" announcing the occurrence in Holland, and requesting a careful examination of any doubtful pink-footed geese shot in Britain. These gees were found wintering in vast flocks at Seistan, in Persia, and in Assam, and it was to this species that the so-called 'pink-footed' shot in India were found to belong, another example of the unreliability of anserine records.

Distinct as is Sushkin's Goose from the Bean Goose, there is yet another member of the genus which to me seems almost more distinct, but to which the majority of British ornithologists do not even grant subspecific rank; it is the Yellow-billed goose, known to continental authorities under the name of *Anser Arvensis*.

The first time I saw Bean and Yellow-billed geese together was at Lilford some years ago, and it amazed me then that the two species could be confused, at least in mature plumage.

The Yellow-bill is very like a greylag in build, but it lacks the pale grey wings, and has yellow legs instead of pink, and the bill is longer and has a black nail. From the Bean the chief points of difference are the shape of the head, which is rounded and not flattened on top like that of the Bean, and the bill, which is completely different in shape, size, and colouring, being in the Yellow-bill four and a half to five times the length of the nail, which is almost circular; while the bill of the Bean is only three to three and a half times the length of its nail, which is narrow and elongated. Moreover, in the former the bill is larger, stronger, and slightly arched on the bridge, as opposed to the slender, slightly 'shovel-shaped' bill of the latter. In all the examples I have seen the plumage is quite distinct; that of the Bean is greyish, darkening to black on the back and wings, the tertiaries being black broadly edged with white. The ground colour of the Yellow-bill is brown, the feathers being narrowly edged with buff, so that the barred effect of the Bean is largely absent, and the tertiaries are brown, dark, but not black. But here, as always where geese are concerned, a comparison with skins, or far better, with living birds, when that is possible, is worth ten times the value of the best descriptions ever written.

I have perhaps given this species more prominence than it deserves, but it is a fairly common British bird, which, according to a number of British authorities, exists only in the imagination of a few misguided enthusiasts; fortunately one member of a flock of such 'imaginations' which spent the whole summer of 1931 in the Estuary of the Tay, was caught when in full moult and unable to fly, and is now in my collection of tame wild geese, where its contrast in voice and habits, as well as in appearance, to those of the Bean geese, can be easily observed.

Conclusion.

I see that I have already taken far more time than I had intended, so I will end by a brief summary of the chief points about which I have tried to speak.

First of all, I think that the solutions to most of the problems connected with the satisfactory identification of wild-geese are to be found on their nesting grounds; it sounds brutal, but what we need are far more geese shot, or better ringed, on the nest. Plumage variations can, and are being worked out by breeding in complete, or partial captivity, but until these experiments can be correlated with a knowledge of the breeding places and migration routes of each species or type, it will be impossible to settle such questions as to whether polymorphism exists in the Brents, and whether their geographical separation warrants the numbers of races of Bean-geese which certain writers have claimed to exist.

But a great deal of work can be done in this country by keeping a sharp look-out for any unusual birds, and by the collection of as much data as possible, however unimportant it may seem. For example, if a Brent is examined it is important to describe as accurately as possible the colour of the breast, and of course, the locality where it was obtained; with the grey geese, especially the Bean-geese, of which a bewildering number have been described, the shape, size, and colouring of the bill, is the chief point to notice.

Statistics may be as dull as ditch water, but they are the essential sources from which the River of Knowledge must ultimately spring.

XVIII.—*Silviculture.*

By ERIC ANNANDALE, B.A.

(Read 12th February, 1932).

In the same way as Agriculture means the tilling and cultivation of fields, so does Silviculture refer to the cultivation of woods, as distinct from Arboriculture, which refers more to the growing of single trees, such as may be seen in an arboretum, or botanic gardens. Perhaps I might quote what Dr. Schlich says of silviculture, since it is a very good summing up of the subject. "Silviculture literally means the culture of forests, that is to say all measures connected with the formation, preservation and treatment of forests. In practice, however, the word "forestry" is used to express and comprise all this, while by "silviculture," in its narrower sense is understood the formation, regeneration and tending of forests or woods, until they become ripe for the axe."

The treatment of a forest naturally depends upon what the object of growing it may be. The proprietor—often the State—obviously must have some reason for growing his forest, and of these objects I shall mention only a few.

1. The production of the greatest quantity, or best quality of wood, or greatest money return per acre and year.
2. Regulating drainage, e.g. Lake Vyrnwy, Wales.
3. Preventing landslips, e.g. Switzerland.
4. Arresting shifting sands, e.g. The Landes, France.
5. Producing some special by-product, as turpentine or tannin.

In each of these and other cases the particular species of tree to be grown and the method of treatment are likely to differ and it is the business of the Forester to select those species and methods which realise the object of management most fully, and in the most economic manner.

The matter of light and shade is of primary consideration in deciding which species to plant, as are also the soil desires of the different kinds of tree. Some trees, as beech, will stand a considerable amount of shade, whereas others, for instance larch, require a fair amount of light throughout their life. This fact is borne in mind when considering the desirability of forming mixed woods, thereby keeping the forest floor sufficiently covered. When a crop of light-demanding trees is in existence they may well be underplanted with a shade-bearing species.

In Great Britain it is usually necessary to plant up an area with young trees, since it is not possible to rely upon natural seed

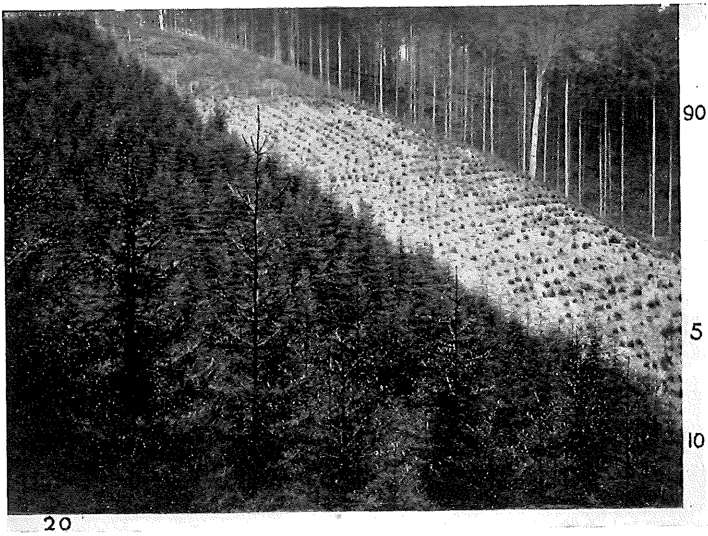


PLATE XVIII.

regeneration from the standing forest. For obtaining the seedlings nurseries are used, although it is also possible to broadcast seed over the forest area.

The following are the Silvicultural systems in common use, particularly on the Continent of Europe.

A.—High Forest Systems.

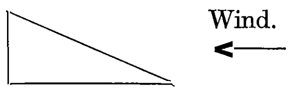
1. Clear-cutting System.
2. Uniform, or Shelterwood Compartment System.
3. Group System.
4. Strip System, and variations of it.
5. Selection System.
6. Storied High Forest.
7. High Forest with Standards.
8. Concentrated regeneration in Irregular Forests.

B.—Coppice and Pollard Systems.

9. Simple Coppice.
10. Coppice with Standards.
11. Pollarding.

1. Clear Cutting System.—that usually to be seen in this country. Each year a certain area of forest is clear-felled and replanted. Imagine an area of 100 acres divided up like a chess board. One acre is felled each year and replanted in rotation for 100 years. Thus a regular yield of trees 100 years old is produced annually. The length of rotation will vary according to the species. In the case of conifers it is better not to fell adjacent areas in consecutive years, and the forest may be divided into several cutting series. The reason for this is that injurious insects breed in the stumps of the felled trees and pass on to the young trees. After a period of five years the stumps will have rotted and the danger is not present. In the accompanying photograph (Plate xviii) may be seen the old wood on the right. Then comes a strip of trees some five years old, recently planted. Next to them are those planted ten years ago, and in the left foreground are 15 year old trees. It is preferable to arrange the direction of the cutting series against that of the prevailing wind. In the illustration the prevailing wind is from the right and the exposed raw edge of the old stand will not suffer : were it from the left considerable wind damage would certainly occur.

Further, imagining that the next felling brings one to the end of the cutting series, the series in vertical section will have the form of a wedge facing the prevailing wind, which is diverted up over the forest without doing damage : thus



2. Uniform, or Shelterwood Compartment System.—The forest is divided up into a number of blocks, or compartments, and is regenerated *naturally* under the shelter of the old crop, which forms a shelterwood and is retained for some years until the young trees are firmly established. The regeneration is effected by the seed falling from the old trees on to the ground beneath. The old stand is opened out, the best trees being left scattered over the area to act as mother trees. As the light penetrates to the ground, the bare forest floor becomes covered with seedlings. In practice trees do not seed prolifically oftener than every three or four years, according to species, so that a period, up to perhaps 15 years, may be required to effect the regeneration of any one block. In later life this age difference is disregarded and the wood, for all intents and purposes, looks, and is considered as, even-aged.

This system is particularly applicable to trees with heavy seed, such as Beech, which only falls on the ground beneath the mother trees, and is not wind-borne.

Most systems have disadvantages, and the best is chosen according to the object of management and the locality. The accompanying illustration (Plate xix), shows a disadvantage of the Shelterwood Compartment System, applied in this case to Scots Pine. A serious windfall has taken place after the seeding felling has been made, and many of the mother trees have suffered. Trees, which during their whole life have been protected by their neighbours, when suddenly exposed to a strong wind, are liable to fall, because their root system is not developed to stand this strain, and also their centre of gravity is higher than in a tree grown by itself, with branches from apex to near the ground level. One of the reasons, of course, of growing trees close together is to obtain clean boles free from side branches, which cause knots in the resulting timber.

3. Group System, which is a modification of the Shelterwood Compartment System. In a similar manner the forest is divided up into a number of periodic blocks, but the management is less hard and fast than in the previous system. If young growth, seeded naturally from the old trees, is observed coming in, a group may be started there and the surrounding old wood gradually felled outwards in a circle round it into the old wood. An advantage of this is that the young growth is not damaged by felling operations, which is inevitable to a certain extent in the Shelterwood Compartment System. This system, however, is not used extensively, owing to its disadvantages, among which may be mentioned the amount of attention required in continually opening out groups till they meet all over the forest. Also damage by wind to the old crop and by sun to the unshaded young crop is apt to be serious.

PLATE XIX.

4. The STRIP SYSTEM is very similar to the Clear Cutting System in theory, but one relies on a natural, instead of artificial, regeneration. The forest is divided into a number of cutting series and each is treated similarly. A strip is felled along the outer edge of the rectangular series, starting at the end opposite the wind direction, for the reasons already stated, and also that the seed from the old trees may be blown on to the felled area and there take root. This is a very popular system, since a regular annual yield is obtained and there are virtually no serious disadvantages. It is extensively practised in the Black Forest in Germany and is subject to various modifications. One of these is when the felling proceeds from North to South, the prevailing wind being more or less West, the felling is made in "steps," looked at in plan from above, thus there is protection for the young growth from the wind on the West and also from the sun in the South, for drying up and death among the seedlings is very severe if there is no shade available in these warmer countries.

5. SELECTION FOREST.—The Selection System entails an uneven aged forest from which each year are cut the trees which have reached a certain specified size. In practice one cannot go over the whole forest annually, so that a forest is divided into a number of "felling cycles," one of which is dealt with annually in turn. This system is only applicable to shade-bearing species of trees, since those requiring considerable light to allow of their growth could not regenerate in the comparatively heavy shade of the old wood. Owing to the heavy expense entailed in management, this system is really only used where it is essential to keep forest on the ground the whole time to prevent landslides, avalanches, etc., in mountainous country. In other words it is a Protection Forest and the system is the outcome of the required object of management. It is also used in primitive forests, where only the best—say Teak—trees are cut out when they have reached the required size.

6. STORIED HIGH FOREST consists of a wood of two storeys. A wood of light-demanding trees is thinned out and under-planted with a shade-bearing species. The age at which this should take place varies according to species. With Larch it should be at twenty to thirty years, for example, and in the case of Scots Pine, at, say, thirty to fifty years.

7. HIGH FOREST WITH STANDARDS consists of working the Forest under some recognised system—say Clear Cutting—but leaving some twenty of the old trees per acre still standing for a second rotation with the object of obtaining extra large timber.

9. Briefly, the above give an idea of some High Forest Systems. Passing on to Coppice, only trees capable of producing coppice shoots from the stump can be considered. Large areas of Oak coppice, for instance, are grown with the object of producing

bark from which the tannin is extracted. The old tree is cut as near to the ground as possible to allow of the shoots coming away from the root collar, and with the cut at an angle to prevent rain collecting on the stumps and causing rot. Possibly a fifteen years rotation is used, the coppice being felled every fifteen years. The coppicing power of the stump gradually diminishes, but with a fifteen years rotation it is found that five or six crops can be taken.

10. Coppice with Standards, in the same way as High Forest with Standards, means leaving a proportion of the old trees standing instead of felling all to obtain coppice from the stumps.

11. Pollarding is virtually obtaining coppice shoots from some distance above the ground. In England many pollarded Willows may be seen, the shoots appearing at the place where the higher part of the tree has been cut off. This is useful in marshy ground.

These notes are, of course, by no means complete, and in the perparation of the Working Plan of a forest area, local conditions of climate, availability of labour, methods of transport and market, etc. will govern what system of obtaining the desired result will be used.

XIX.—*Perthshire Hieracia.*

By E. SMART, B.A., B.Sc., F.R.S.E.

(read March 11th).

I have for some time been giving attention to the genus, *Hieracium*, one of the most puzzling of the genera included in the order *Compositae*.

The characteristic features of the genus—an *imbricated involucre*, *ligulate* and perfect florets, *achenes truncated*, *angular or striated*, *pappus pilose* and *brittle* in one row and of a tawny white, or brownish colour, receptacle dotted without scales—render it easy to decide whether the plant belongs or does not belong to the genus. The difficulty arises when we seek to determine the species. While identification of some species may be at once determined from the general appearance of the plant, in many others the differences between them are so slight, in many cases not more marked than the variations from type in individuals of the same species, that some botanists would reduce the long list of species included in the genus by those who have made it their special study to a comparatively few standard forms. Thus we find in the 1924 edition of Bentham and Hooker's Flora, revised by Dr. Rendle of the British Museum, the number of species reduced to seven. "Most of the species" we read in this Flora "are very variable, and specimens are frequently found intermediate between some of the commonest ones. In the attempt to classify these forms, and to give greater exactness to their definitions, modern botanists have distributed them into a long number of supposed species, amounting to 100 for Britain alone (see W. R. Linton's account of the British Hieracia, 1905); but the difficulty of distinguishing them appears only to increase with their sub-division."

In Hooker's Flora we find ten distinct species, other specimens being described as varieties and sub-species. "I believe," says Hooker, "that there are no characters whereby the 9 forms from *alpinum* to *boreale*, inclusive, can be more than approximately defined."

The attitude of Dr. Buchanan White to this genus appears in the following remark made by Professor Traill, of Aberdeen University, who edited White's Flora of Perthshire, "to Dr. White as to most botanists this genus was too formidable to be lightly undertaken, while the labours of specialists in Great Britain and on the Continent of Europe in recent years have made it impossible to rely on earlier records, unless these can be substantiated by references to the actual specimens. The genus, like a few others, had been left by him for revision after the greater part of this work was completed, and his notes on it were of a very imperfect kind."

Probably one of the first to make a close examination and study of the various species of this genus to be found in this country was James Backhouse, and the result of his labours as it appeared in his monograph of the British Hieracia, published in 1856, was a reliable contribution towards the determination and classification of the different species. Backhouse's monograph seems indeed to have been the standard work upon the subject for many years, but succeeding botanists who made a special study of this interesting genus felt that a greater differentiation was needed. One of the most indefatigable and painstaking workers amongst these specialists was Mr. Hanbury. In 1894 he published in the Journal of Botany a list of the British Hieracia which would, in his opinion, form a systematic guide to the genus. This list of species and varieties amounts to more than two hundred, and seems rather formidable to a beginner in Botany. The difficulty of determining many of the species is undoubtedly increased by the greater sub-division. Hanbury seems to have fully appreciated the difficulty of distinguishing between many of the species; and in this connection, referring to the work of Dalstadt and Elfstrand on the Scandinavian Hieracia, he says "While fully appreciating the prolonged, painstaking honest work, which seems shortly destined to result in the enumeration of nearly one thousand named forms for North Europe, I feel it necessary to express a grave doubt as to the practical utility of such sub-division, and my fear that the only effect will be to dishearten the student and render the study of a wonderfully attractive and interesting genus an impossibility, except to the few specialists who may devote their entire lives to its elucidation."

These references show that the study of the Hieracia demands extremely careful and close observation. The differences between the various species are often indeed so slight that it is not surprising to find that even amongst the most competent and skilled botanists there is often much divergence of opinion in the naming of the species to which a particular plant belongs. But the difficulties of determination only serve to render the study more interesting and attractive. One of the recent workers who has taken up the study of this genus, and has bestowed upon it an immense amount of painstaking labour, is W. R. Linton, Vicar of Shirley, Derby. In his book, published in 1904, which gives his account of the British Hieracia, he refers to the work of Hanbury, Williams, and others, to the discovery of new species, and gives a complete descriptive list of the various British forms known at that time. In this account there are enumerated 124 different species, but if we include with these the different varieties, the number of specimens described amounts to not far short of three hundred. This list is much larger than that given by Hanbury, and it seems not at all improbable that with the lapse of years the list may still increase for the genus appears to have a marked tendency to variation. The question of hybridism has been suggested as a possible source of origin of new species. But the researches of Linton rule this out as a cause of the production of new species. Linton collected roots of the various species and cultivated the plants in his garden. He had hundreds of plants of different species growing side by side, and thus every opportunity was given for cross fertilisation. But he failed to produce any permanent hybrid from the seed. When a hybrid did appear he found it quickly reverted back to one or other of the plants from which the seed was produced.

The explanation of the numerous species of Hieracia is not therefore to be explained by hybridism. The tendency to form new varieties and new species can only be attributed to conditions of climate and situation. The Hieracia are mostly mountain plants, but many species also belong to the lower levels, and are to be found in meadows, on the banks of streams, etc. The plants growing under the more favourite conditions of climate and soil differ very markedly from those growing under the harsher and more trying conditions of the higher mountain slopes. The growth of the former is much more luxuriant, and there are usually many flower heads. The Alpine and sub-

Alpine species are smaller, very often shaggy in appearance, and with few flower heads. The wool and hairs which are to be found on the stem, petiole, and leaves, probably serve for some kind of protection, conserving heat and moisture, while the large and well developed few flower heads (often single) would compensate for the smaller number of flowers. In fact we have here a fine example of the principle of adaption to environment and the means adopted to secure preservation of species in the struggle for existence.

In determining the species to which a specimen may belong we have regard first to the general appearance of the plant, then in detail to the character and distribution of the leaves, the stem, the nature of the alveoli, of the receptacle, the edges of the pits being characteristically marked in many species, the hairs, etc. to be found on the stem, leaves, etc., the appearance of the involucre, the ligules, the style, the nature of the achene, etc. But often when all these have been sufficiently noted there may be still difficulty in fixing the species for no single plant conforms to type, and there is so fine and continuous gradation of species that the line of demarcation between the different forms is not easy to fix. In fact, one must be guided by the balance of evidence and assign the specimen to the species to which it seems most closely approximate.

In the short time that I have given to the study of this genus I have only been able to visit comparatively few localities. I have been on Ben Lawers, Schiehallion, Ben Voirlich, in Glenartney, on the banks of the Bruar and Lochay, and, of course, have searched the roadside, etc., round Perth. I have also gone over the collection of Hieracia in the Herbarium.

In White's Flora we find a long list of different species of Hieracia, but many of these have been named from dried specimens, and, unfortunately, in such specimens, those characteristic features of the living plant, which play so large a part in determining the species, are dried up, and so altered as to be useless for identification purposes. It is not surprising, therefore, to find that there has been sometimes considerable differences of opinion in identifying the dried specimen. Not infrequently you find the first suggested name erased, and a second, or a third suggested. In such cases one must conclude that the evidence has not been sufficient for identification, and that the plant must be rediscovered before it can be definitely counted as among the Perthshire Hieracia.

The species referred to in this paper are either those which I have personally collected or those selected from the Herbarium, about which there can be no dubiety and which are sufficient to illustrate the grouping and classification of the genus. And I have followed the arrangement made by Linton—an arrangement to which he arrived after years of investigation, research, and study, and which I consider well devised for facilitating the study of this wonderfully interesting group of plants.

We have then the division of the genus into the two main groups of I. *Pilosella,* and II. *Archieracium.*

The *Pilosella* sub-divided into *Pilosellina* and *Auriculina* includes only three species, and of these *H. pilosella* is not infrequent in Perthshire. *H. aurantiacum* must be regarded as originally an outcast from gardens, and not as a genuine wild species.

H. pilosella is to be found on dry, heathy banks, at the roadside, on rocks, etc., wherever it can get a suitable footing. The plant, easily recognised from its general appearance, is usually barely a foot high, and has a characteristic stoloniferous rootstock, or rhizome. It is covered with soft hairs, the underside of the leaves being especially woolly, or downy. The scape is leafless and bears one flowerhead, the ligules are yellow, the exterior ones being striped on the outside with red or brown. Styles yellow—margins of the pits of the receptacle denticulate—achenes small and crenulated at the apex.

The second main group, the *Archieracium* is sub-divided, first of all into the (a) *Phyllopoda* and (b) *Aphyllopoda.* The former as the name indicates includes those species whose leaves are radical, the flowering stem having no leaves, or only one or two. The second group includes those species which have either no radical leaves or radical leaves which wither and disappear early, and a flowering stem which bears numerous leaves.

The very numerous species included in these groups are further sub-divided for convenience of identification, into various subgroups. Under *Phyllopoda* we have :—

(a) *Cerinthoidea.*
(b) *Alpina.*
(c) *Oreadea.*
(d) *Vulgata.*
(e) *Alpestria.*

and under *Aphyllopoda* :—

(a) *Rigida.*
(b) *Prenanthoidea.*
(c) *Foliosa.*
(d) *Umbellata.*

Of the *Cerinthoidea* the most frequently met with species, in my experience, is *H. anglicum* (Fries) and its variety, *longibracteatum.* This is the *H. cerinthoides* of Backhouse. It is rather confusing to a beginner to find different names given to the same plant by different botanists.

Of this species I found numerous specimens in that delightful excursion we had to Schiehallion. It is a handsome and conspicious plant, from 1 to 2 feet high. Radical leaves ovate lanceolate gradually narrowed into long shaggy letioles—one or two stem leaves sessile and amplexicaul—peduncles and the bracts, or scales, or phyllaries, as they are termed, of the involucre covered with black-based and glandular hairs—ligules hairy at the tip—style livid—pits of the receptacle ciliated or pilose-flowering scape with two to five large flower heads. The variety *longibracteatum* is smaller with glaucous and glabrous leaves.

Another species of this group, which has been found at Tyndrum, Ben Laoigh, Glenlochay, etc., is *H. iricum.* This is a stouter and more robust plant than *H. anglicum*—stem leaves three to seven in number, not contracted above the base as in *H. anglicum*, flower heads more numerous—ligules less ciliate, often glabrous.

The species belonging to the group *Alpina* differ generally from those of the *Cerinthoidea* in the rhizome not being woolly—the leaves green and not glaucous—flower heads fewer but comparatively large—margins of the pits of the receptacle elevated and dentate. There are, of course, other small differences.

Of *Alpina*, sub-division *Genuina*, I have examined two specimens, *H. holosericeum* and *H. globosum*—the former being the dried specimen in the Herbarium and the other gathered on Schiehallion.

H. holosericeum, found at Stuc-a-Chroin, Ben More, Killin, Ben Lawers, etc., as the name implies, is entirely covered with long silky hairs, does not exceed a foot in height and has one solitary large flower-head—ligules pilose—styles yellow.

H. globosum is a small but handsome plant, about a foot high—leaves with short petioles, dentate and pilose beneath; 0 or 1 stem leaf linear or bract-like—stem woolly and with black-based hairs which also thickly cover the involucre—flower head large and globose—ligules usually slightly pilose at the tips—styles yellow.

Types of the sub-division *Alpina-nigrescentia* are *H. nigrescens*, *H. lingulatum*, *H. sensescens* and *H. chrysanthum.*

H. lingulatum, of which specimens have been gathered at Ben Lawers, Stuc-a-Chroin, Killin, etc., usually about 2 ft. high, is probably the most frequently occurring of these—radical leaves lingulate dentate — stem leaves 2 or 3 lower subsessile—stem pilose with black-based hairs—flower-heads 2 to 4 on long floccose pilose peduncles—scales of the involucre covered with black-based hairs, porrect in bud—ligules subglabrous—styles dark.

H. nigrescens has been gathered on Ben Lawers, Ben Laoigh, etc., is a smaller plant, about 6 to 18 inches high—radical leaves, with large irregular teeth—stem leaves 1 to 2 bract-like—stem pilose, floccose—peduncles stout—phyllaries narrow villous, with black hairs—flower-heads few, 1 to 3—ligules slightly pilose—styles dark.

H. senescens found also on Ben lawers, Ben Laoigh, etc., is another small plant—leaves green lanceolate dentate—stem leaves 0, 1 or 2, narrowly lanceolate petioled—stem pilose, with black-based hairs—flower-heads few—phyllaries woolly at the tip—styles yellow.

H. chrysanthum has been gathered at Ben More, Glen Tilt, Ben Lawers, Glen Shee, etc.—leaves bright green and glossy in appearance—stem leaves 0 or 1, narrowly lanceolate petioled—stem pilose with black-based hairs—flower heads 1 to 3 on short peduncles—phyllaries long, porrect, pilose with black-based hairs—ligules orange yellow—styles yellow.

Of the group *Oreadea* I have selected three specimens from our Herbarium, viz. :—*H. Schmidtii*, *H. lasiophyllum* and *H. argenteum*. The distinguishing features of this group are the glacous, or glaucescent appearance of the plants, the thicker leaves and the usually yellow styles.

H. Schmidtii. The Herbarium specimen was gathered on the banks of the Shee—leaves pilose beneath—stem leaves 0, 1, or 2 sessile lanceolate dentate, often bract-like—stem hairy and floccose in the upper part—flower heads 4 to 5—phyllaries with dark black-based hairs—styles yellow—pits of the receptacle with deeply cut, or laciniate margins.

H. lasiophyllum, collected at Killiecrankie, Rannoch, etc., is, as the name indicates, markedly floccose—stem woolly, with a few black-based hairs—leaves stout, glaucous fringed with long hairs—stem leaves 0 or 1—peduncles floccose with a few black-based hairs—phyllaries with black and glandular hairs—flower heads 1 to 5—ligule tips glabrous—styles yellow.

H. argenteum. Specimens of this have been gathered at Ben Vrackie, Linn of Campsie, Glen Lyon, etc. Stem sparingly flocculose—leaves glaucous—stem leaves 1 or 2 narrow lanceolate—penduncle long and floccose—phyllaries dark with a few black-based hairs—ligules glabrous—styles yellow.

Of the group *Vulgata* there are numerous species. Generally the leaves of the members of this group are green or glaucescent, flower heads more numerous than in the specimens already referred to and much smaller, styles generally livid, achenes small. For convenience of determination this group is further divided into (a) *Silvatica*, (b) *Sub-vulgata*, (c) *Caesia*, (d) *Eu-vulgata*.

Of the division *Silvatica* a typical species is *H. silvaticum*, generally known as *H. murorum* (Linn). Stem usually almost glabrous—leaves thin and membranaceous, truncate or sub-cordate, dentate often pale, glaucous green underneath—stem leaves 0, 1 or 2 ovate acuminate—petioles with long hairs—phyllaries with glandular hairs floccose and some black-based hairs—styles livid. It is frequently met with on walls, banks, rocks, etc., and there are numerous varieties.

H. aggregatum has been found on Ben Chonzie and Ben More. Stem erect and reddish—leaves broad obtuse toothed in the lower part—stem leaves sub-sessile—peduncles erect, crowded together, umbellate—phyllaries floccose, obtuse—styles yellow.

Of the *Sub-vulgata* two species are mentioned in Whyte's Flora as having been found at several localities in Perthshire, viz. :—*H. pictorum* and *H. rivale*, but I failed to find specimens of these in the Herbarium, nor have I ever come across them.

In the division *Caesia* we have recorded for Perthshire *H. caesium v. insulare*, *H. caesio-murorum* and *H. anfractiforme*, or *anfractum*.

H. caesium, found at Am-Binnein and Ben Lawers grows to a height of 1 to 2 feet. Leaves caesious and coriaceous, narrowing to a dentate base-stem—leaves 1 or 2 small and sessile—peduncles flocculose with many black-based hairs, porrect—ligules glabrous—styles livid—margins of pits of receptacle dentate—panicle few flowered.

H. sub-anfractum has been collected at Ben Laoigh and near Killin. Leaves stout, bright green—one stem leaf petioled and deeply dentate—peduncles flocculose with black-based hairs—phyllaries flocculose with black-based hairs—ligule tips ciliate—achenes chestnut coloured.

Of the division *Eu-vulgata* I have taken the two species *H. vulgatum* and *H. orarium*.

H. vulgatum (Fr.) or *H. silvaticum* (Sm.) is probably, with its varieties, the commonest species, occurring everywhere on rocks, banks, roadsides, all over the county. Stem usually sparingly pilose, often reddish—leaves petioled and dentate in the middle, often purplish underneath—stem leaves 1, 2, or 3, upper sessile—flower-heads often many, small—peduncles and phyllaries flocculose—phyllaries with many dark hairs—styles livid or livescent.

The variety *rubescens* is marked by the stout purple stem.

H. orarium has been found near Killiecrankie. Stem pilose—leaves few, pilose beneath, with the upper part triangular and entire, lower part with acute, cusped teeth—stem leaves 2 or 3 lower petioled—panicle small with 2 or 3 arcuate branches—heads few—peduncles flocculose—phyllaries pilose—ligules pilose tipped—styles yellow—achenes black—margins of receptacle pits dentate.

The division *Alpestria* embraces those species which have radical leaves and also numerous stem leaves.

H. Dewari has been found at many places in Perthshire, at Lochearnhead, Glendevon, Glen Lochay, the Lawers Burn, Ben Laoigh, Glen Shee, etc. Leaves yellowish green, pilose, rapidly contracted into short pilose petioles—stem leaves 7 to 9 lower petioled, intermediate semi-amplexicaul, upper amplexicaul—peduncles slender, incurving, with a few black-based hairs—flower-heads few—phyllaries with black-based white hairs—ligules pilose at the tip—styles dark.

The various species of the group *Aphyllopoda* have, as already stated, numerous stem leaves and no radical leaves, or radical leaves which wither away early. This group is sub-divided into (a) *Rigida*, (b) *Prenanthoidea*, (c) *Foliosa*, (d) *Umbellate.*

Of the *Rigida* I have not yet seen any specimens, though *H. gothicum* and *H. sparsifolium* are given in Whyte's Flora.

Of the *Prenanthoidea, H, prenanthoides* is frequently met with at such places as Blair-Atholl, Moulin, Glen Tilt, Rannoch, Ben Lawers, Loch Lubnaig, Glen Almond, etc. Stem leaves, lower petioled, winged and clasping at the base, middle panduriform amplexicaul, uppermost decreasing to bracts—peduncles floccose and glandular—flower-heads numerous—ligules pilose—styles dark—achenes chestnut coloured—margins of pits of receptacle deeply dentate.

Of the division *Foliosa* the Herbarium contains specimens of *H. strictum, H. corymbosum, H. auratum, H. crocatum* and *H. boreale.* The general features of this division are the lower leaves with a narrow base, upper leaves sessile with a broad base, ligules usually glabrous, styles livid and achenes dark.

H. strictum has been gathered at various localities in Perthshire. It resembles somewhat *H. prenanthoides.* Flower-heads few—phyllaries pilose, floccose—ligule tips ciliate—achenes chestnut coloured.

H. corymbosum has been gathered at the Balvaig, the Lawers Burn, Linn of Campsie, etc. Stem slightly floccose, often purplish—leaves many, lower with winged petioles, middle semi-amplexicaul, upper amplexicaul, all dentate—phyllaries with white hairs up the middle and pale margins—styles livid—pappus rufous.

H. auratum gathered also at many places in the county, resembles *H. corymbosum*—styles yellow.

H. crocatum not so frequent as *auratum,* has been found at Ben Lawers, Loch Lubnaig, etc. Stem pilose—leaves, lower narrowed to a clasping sub-petiole, upper half clasping—peduncles floccose, with a few black-based hairs—flower-heads 5 to 12—phyllaries dark, with a few dark hairs—styles livid.

H. boreale has been found on the Woody Island, at Loch Lubnaig, Loch Earn, etc. Stem stout, reddish, 2 to 4 feet high, pilose below and woolly above—leaves, lower dentate and petioled, upper broad and sessile—flower-heads many—phyllaries black, almost glabrous—styles dark.

The division *Umbellata* contains *H. umbellatum* and its varieties.

H. umbellatum has been got at Stormontfield, Glen Lyon, Glen Lochay, etc. Stem 1 to 2 feet high, hairy and shaggy below—leaves all similar, sessile, narrowly linear, base toothed—peduncles flocculose, dilated at the apex—phyllaries with many tips recurved—styles yellow—panicle umbellate—achenes chestnut to black.

There are of course many other species which have been recorded for the County, but those I have mentioned are, I consider, representative, and sufficient to show the wide variety of this interesting plant to be found within easy reach of our own doors.

XX.—*The Petrography of the Lower Old Red Sandstone Lavas in the Neighbourhood of Tayport.*

By HAROLD PIRIE.

(Read February 10th, 1932).

Introduction.

The lavas described in this paper lie within the area extending southwards from Newport and Tayport to St. Michaels, the area thus delimited forming an approximately isosceles triangle—roughly four square miles in extent—whose base lies along the southern shore of the Firth of Tay. To the eastwards the area is bounded by the flat alluvial plain of Tentsmuir, while to the West the Newport-St. Michaels road is taken as an arbitrary boundary.

The land rises fairly steeply from the coast line to the wooded hills (300 ft.) behind Newport and Tayport, which form the eastern continuation of the southern limb of the Tay anticline, and thereafter falls gradually to the southward. The terraced topography, typical of the Old Red lava districts is but feebly developed, and the terminations of the individual flows are not indicated by escarpments. The lavas, however, are well exposed on the coast section and in numerous old quarries inland. Cliff exposures are available on the hills overlooking the Firth, but the lower levels are covered by glacial material.

Previous Literature.

A description of the general field characters of the lavas, and of the shore section below the West Lighthouse, was included by Geikie in the East Fife Memoir (1), and the rocks from Causewayhead and Northfield have been described and figured by Durham with petrological notes by Judd (2). The British Association Handbook (1912) contains an account of the Lower Old Red Sandstone rocks of Fife, in which the work of Geikie and Durham is summarised, with additional notes by Balsillie and Craig (5).

Age of the Lavas.

The lava series extends westward along the shores of the Firth, and near Balmerino they are intercalated with fossiliferous sediments. In particular, a dark shale, six feet thick, has yielded *Mesacanthus Mitchelli*, *Ischnacanthus gracilis*, *Climatius scutiger*, *Pterygotus* sp., *Kampecaris forfarensis*, and *Parka decipiens*. This fauna, coupled with petrographical evidence, enabled Geikie (3) to assign the lavas to the Lower Old Red Sandstone.

Field Characters.

Few interesting structures are displayed by the lavas under review. Among the compact varieties rectangular jointing is frequently exhibited and in some cases a platy structure is developed by the increase in the number of the horizontal joint planes. The lavas usually weather along these joint planes, but a small scale spheroidal weathering has been observed. Sometimes, too, the rocks have been converted into a shaly material, occasionally with the yellow colour also observed among the blocks in the associated conglomerates.

Characteristic, too, are the veins of haematite traversing the andesites, usually along the joint planes, but also at random throughout the mass of the rock. They are well displayed in the platy varieties where they give rise to parallel horizontal dark red streaks, and the joint plane may be coated with a bright red layer. In the compact rocks it is sometimes observed that the upper parts of a flow are richer in haematite than the basal portions. In thin section the rock is seen to be replaced by iron oxide, and although the felspars remain fresh, the olivine phenocrysts, when present, are readily affected.

Interbedded with the lavas are frequent layers of conglomerate and volcanic breccia, usually thin and impersistent, representing the intervals between successive eruptions. More remarkable are the infillings of sedimentary material occupying cracks in the lavas, and consisting of green micaceous sandstone veins, figured and described by Geikie. Less common are the grey more ashy bands, which, yielding to weathering less readily than the lavas, stand out as ribs from the surface of the latter.

Geikie regarded the lavas as subaqueous outpourings, but the above phenomena would seem to lend support to Mr. Smith's views (4) that the flows were erupted subaerially, and that the veins of sediment and of ferric oxide were introduced by the waters of temporary pools, the iron being derived from the lavas themselves. Moreover the fact that no definite pillow structures have been detected accords well with Mr. Smith's interpretation.

The rocks are almost wholly lavaform, intrusions being extremely rare. This is all the more remarkable when one considers the abundance of dolerite sills intruded into the Carboniferous strata immediately to the southward. Apparently the injection of such bodies is connected with the depth of cover, and the necessary conditions in this respect were fulfilled in the Carboniferous area immediately to the southward and in the area of Old Red rocks around Dundee. The intervening strip of lavas, now under discussion, did not carry the necessary load of superincumbent strata to permit of such intrusion.

From the peculiar, almost concentric, jointing of the andesite in a quarry at Causewayhead, Durham assumed it to represent an old volcanic neck. Apart from this, however, no evidence of the presence of actual vents has been obtained, although the occurence of large blocks in the agglomerates suggests their close proximity.

Although only one fault of importance has been recognised, namely that in the cliffs below Newport, minor planes of weakness are abundant, represented by vertical veins of calcite, often with attendant brecciation, or by slickensiding. In the latter case, thin section reveals the shattering of the felspars together with a considerable development of quartz.

Petrography of the Lavas.

In the field the whole series presents a monotonous aspect of one uniform dull grey. In detail, however, the flows vary from pink to purple and steely grey, the colour often changing within the limits of a single flow. They grade from dense compact rocks to highly amygdaloidal varieties, and in many cases it can be shown that the upper portions of a compact flow become highly vesicular, the long axes of the vesicle being orientated in the direction of flow.

These amygdales are filled with a variety of secondary minerals, among which agate and calcite are predominant. Agates are especially abundant in the rock in front and to the west of the East Lighthouse. The filling sometimes consists of a green earthy mineral (caledonite), and the same substance forms the matrix of patches of fine breccia, imparting a mosaic appearance to the rock.

An interesting and beautiful rock occurs at Tayport Harbour at the extreme east end of the shore section. This lava is a dark iron, rich variety, and the uppor portions are extremely amygdaloidal. The vesicles may reach two inches in diameter, and the filling consists of an outer layer of bright red jasper surrounding a central portion of clear calcite.

A further characteristic, frequently seen in these rocks which carry haematite veins, is the presence of small red spots, easily recognisable in the hand specimen. Miscroscopic examination reveals them as pseudomorphs after olivine and less frequently rhombic pyroxene. The replacing material is usually haematite dust, but several sections show the olivine pseudomorphed by reddish brown iddingsite, faintly pleochroic and with a well developed basal cleavage.

Microscopic characters afford a basis of classification into two main types, depending on the presence or absence of olivine :—

(1) Pyroxene Andesite.
(2) Pyroxene Andesite with Olivine.

* Apart from this discriminating feature the two types are indistinguishable. The felspars of the olivine bearing types are no more basic, nor are the ferromagnesians any more abundant than in the simple pyroxene andesites. The following description, therefore, applies equally well to both types.

Structure.

Almost invariably the base of the rock consists of a typically andesitic felt of felspar laths, scattered grains of pyroxene and iron ore, with frequently a certain amount of glassy material, usually devitrified. The ferromagnesians may, however, be almost entirely absent. Porphyritic structures are commonly developed, and a single slice may reveal phenocrysts of felspar, augite, hypersthene and olivine. Rocks porphyritic with respect to olivine frequently carry also porphyritic hypersthene, but large olivines are rarely associated with felspar and augite. The Phenocrysts show a tendency to cluster in glomeroporphyritic aggregates, usually consisting of equidimensional augite crystals, with which hypersthene and felspar may be associated. In the rock from Northfield these aggregates attain a considerable size (3 mm.), individual augite plates measuring 1 mm. across.

Felspar.

Felspars may occur in two generations. Rocks, porphyritic with respect to this mineral are fairly frequent, but they occupy no definite position in the lava series. Elongated prismatic phenocrysts usually exhibit lamellar twinning, while concentric zoning is more characteristic of the platy crystals.

An optical examination of the felspars was made from a selection of slides taken from different parts of the area. It was found that the refractive index varied but slightly from the average value

* It may be contended that the lavas here described are basaltic rather than andesitic in nature. The use of the term andesite however is justified by consideration of the nature of the felspar, and of the paucity of the iron ore and ferromagnesians generally. Even in the more basic types the olivine is never present in large amount, and is invariably porphyritic. Moreover, as will be shown, these lavas, although not identical with, closely resemble the andesites extruded from other centres of Lower Old Red Sandstone vulcanicity.

(n=1.561). The felspar may thus be described as $Ab_{53}An_{47}$. Infrequent plates of Orthoclase are also to be found.

In the non-porphyritic andesites (e.g. Kirktonbarns) the felspars build broad stout prisms, and in these types the development of glass is noticeable. The hyalopylitic structure of the closely packed laths is more characteristic of these types which carry megaphenocrysts. In some cases (e.g. Northfield) the laths present idiomorphic outlines and stand out clearly from the base—flow structure being particularly evident—but in others the felspars are poorly individualised, and appear to merge into the glassy base. Indeed it is common among these rocks to find the felspars invaded by the glass, with the consequent loss of their euhedral form. Sometimes also, the glass forms a ring of orientated inclusions round the margin of a felspar phenocryst and may even invade the entire crystal (No. 75).

Augite.

Again, two generations may be present. The phenocrysts tend to cluster together, but individual plates are not uncommon. The augite is colourless to pale green, characteristically twinned with central lamellae. In the ground mass this mineral occurs as rounded granules which may be distinguished from rhombic pyroxene by their almost invariable freshness.

Hypersthene.

The andesites very rarely carry fresh hypersthene, an exception being the rock from Northfield. In one slide from this locality a large hypersthene phenocryst was found, only partially serpentinised, exhibiting the characteristic straight extinction and the pink-green pleochroism. It commonly alters to serpentine or chlorite, and its former presence is generally indicated by the occurrence in the ground mass of green chloritic patches. Not infrequently there occur rude vestigial parallelograms of haematite indicating former phenocrysts of rhombic pyroxene, with the development of the prism faces.

Olivine.

Although many of these rocks are olivine bearing, this mineral never occurs in large amount, and, when present, is invariably porphyritic. Fresh olivine has not been found; it is commonly pseudomorphed in iddingsite (vide supra), or the trace of its characteristic hexagonal outline may be left by a rim of iron ore. Less frequently serpentinous pseudomorphs occur—the alteration has evidently proceeded beyond that stage.

Note.—The invariable altered condition of the olivine in the Tertiary basalts of Mull has been ascribed by Bailey and Thomas to autometamorphism, and it seems probable that the Tayport lavas have been similarly affected. (Tertiary and Post-Tertiary Geology of Mull, Loch Aline, and Oban, p128, etc.).

Iron Ore.

Magnetite is never abundant, but is of common occurrence as scattered grains, formless or cubic in outline. Haematite occurs frequently in veins or ragged patches of varying size, and as decomposition products of the femic minerals.

Other Minerals.

Interstitial primary quartz is a fairly common, but always subordinate constituent. Secondary, silica may often be seen filling amygdales, associated with chlorite and green earthy caledonite. The rocks may be traversed by thin quartz veins, and here the mineral is accompanied by green fibrous bastite. Accessory apatite is of widespread occurrence in minute, highly refracting needles : biotite has been observed in one andesite only (Laverock Law).

Shore Section.

The Lower Old Red Sandstone Volcanic Series of Fife consists of two minor subdivisions :—

(1) Lower, or Sedimentary, Group.
(2) Upper, or Lava, Group,

the junction being taken at the top of the conglomerate between the East and West Lighthouses at Tayport.

The lower and thinner group is characterised by the abundance of intercalated material. It is represented within our area by the shore section westward from the conglomerate, probably forming a faulted continuation of the Scroggieside succession (Balsillie, loc. cit.).

The upper group is almost wholly andesitic, with little fragmental material. It is represented on the shore eastward from the conglomerate, by the highest lava at Newport, and probably by most of the inland lavas.

A complete sequence is available in the cliffs below Newport and Tayport, but the intervening strip of sand obscures all but a few scattered exposures. A detailed description of the shore section has been prepared, but, being of little petrographical value, it is omitted from the present paper.

The whole series dips to the south-east, the apparent westward dip on the Newport shore being due to the oblique section, made by the northerly trending shore line. About Greenside Scalp the coast swings round to an east-west direction, and the lavas and conglomerates below Newport are exposed again on the beach beside the West Lighthouse. In particular, the thick pyroclastic accumulation immediately west of the West Lighthouse is represented by the conglomerate at Eel Craig, and at Newport the dividing conglomerate has been faulted down to an adjacent position. The evidence for this correlation is afforded by the similarities of the conglomerates themselves, and the resemblances, macroscopic and microscopic, of the andesites above and below. (See fig. 2).

Inland Exposures.

The lavas may also be studied in old quarries, and in occasional natural exposures on the high ground. Fresh material, however, can only be obtained from the former source, the prevalent red colour of the inland lavas being due to the replacement of the feeromagnesians by iron ore, which obscures altogether the nature of the rock. It is of economic interest to note that none of the quarries are at present exploited, it being cheaper to use the Lucklaw Hill felsite or material from the gravel pits.

Owing to the scattered nature of the outcrops, an accurate succession cannot be established, but a tentative correlation with the shore section is suggested below.

A unique and conspicuous rock is the red and white amygdaloidal andesite exposed at Tayport Harbour (No. 39). Now it has been found that this lava occurs in situ on Roseberry Hill, and in a small quarry immediately north of Scotscraig House. These three exposures lie on an approximately N.E. line, indicative of the strike of the lavas, and in agreement with the general S.E. dip. Supporting this conclusion is the fact that the lower portions of No. 39 are microscopically identical with the lava exposed in Roseberry Hill quarry below the red and white rock (No. 60). Further, the underlying olivine andesite (No. 38) which forms the Well Craig may well be represented by Nos. 105-108.

Presumably above these in the sequence and hence unrepresented on the shore, is the lava forming the hill above the farms of Kirktonbarns and Easter Friarton (Nos. 54, 55, 56, 58, 59). The microscope reveals stout prisms of felspar with subordinate ferromagnesians set in a dark glass full of iron microlites. Conspicuous also are interstitial areas of a yellow isotropic glassy material. The crag of Priestcraig, however, consists of a more acid type (No. 57), thin section showing a considerable development of primary quartz.

A complex group of exposures are those in the wooded heights to the east of Newport. The most interesting type is that from the large quarry on Laverock Law—the only biotite bearing andesite recorded from the district. It is a fairly coarse rock, consisting of ill-defined felspar phenocrysts, set in a ground mass of poorly individualised laths, together with a certain amount of devitrified glassy material. Augite is abundant in pale green idiomorphic granules, and rhombic pyroxene in more elongated crystals. The iron ore occurs in scattered grains, and in large ragged areas. There are also in evidence sparse flakes of intensely pleochroic brown biotite, in several cases wrapping round the pyroxene. Accessory apatite builds highly refracting needles, and interstitial quartz is present in small quantity.

In the quarries and field exposures above the farm of Northfield, there occurs a beautiful rock carrying glomeroporphyritic pyroxene aggregates distinguishable even in the hand specimen. The base consists of felspar laths in fluidal arrangement with the usual granular pyroxene and iron ore. This type is also represented by the andesite of Tofts Law.

Comparison With Other Areas.

Although no detailed comparison of other Old Red Sandstone volcanic centres can be attempted with the limited area here described, nevertheless, certain points of interest arise.

The Tayport andesites are but another example of the restricted petrographical range of the L.O.R.S. lavas of the north-east portion of the Midland valley. The lavas on the north side of the Firth (8) are in all respects similar, and both areas appear to be typical of the Ochil and Sidlaw groups generally in the small development of the more acid types.

Closely comparable in this respect are the Carrick volcanics, as described by Tyrrell (6), while the lavas around Montrose (7), although in general more basic, approximate to the andesitic type in those examples poor in olivine.

Other centres, however, show a much greater variety. Thus in the Cheviot area, although augite hypersthene andesites are predominant, trachytes and rhyolites are also common. Again the neighbourhood of St. Abb's Head exhibits pyroxene andesite along with other more acid lavas and intrusives. The lavas of the Pentlands, of Lorne and Glencoe, also show this diversity of type foreign to our area.

It must not be forgotten, however, that at Tayport and in other regions where acid types are subordinate, proof of their former existence is afforded by blocks in the intercalated conglomerates.

Mr. C. F. Davidson (9) has recently shown that the neighbouring lavas of Moncreiffe Hill are basaltic in nature, and finds a remarkable development of Orthoclase. Although this is parallelled by the lavas of Lorne, orthoclase is rare in the Tayport district.

The abundance of vesicular lavas, with their elongated amygdales, filled with calcite, agate or "green earth," the iddingsite mode of alteration of the olivine, the numerous shaly or sandy vein-fillings, and the impersistent sediments are but further proof of the general uniformity of conditions prevailing during the lava eruptions of Lower Old Red Sandstone times.

SUMMARY.

1. The lavas, erupted from the Ochil-Sidlaw centre, have been shown to belong to the Upper (Lava) and Lower (Sedimentary) Groups of the Lower Old Red Sandstone Volcanic Series.

2. Both divisions are represented on the shore section. The swing of the coast line causes the lavas at the West Lighthouse to be repeated in the cliffs below Newport, where the lowest andesite of the Upper Group is faulted down against the Lower.

3. The inland exposures are described and a suggested correlation offered with the shore section.

4. The predominant petrographical types are pyroxene and olivine andesites; only one biotite andesite is recorded.

5. An optical examination of the felspars shows their composition to be $Ab_{53}An_{47}$—a fairly basic andesine.

6. A comparison with other areas indicates a close similarity with the lavas of the Carrick Hills (6). The lavas of the Montrose centre, described by Jowett (7), are in general more basic, both with regard to the composition of the felspar and the amount of olivine present. The rocks described by Harris (8) from the north side of the Tay, are in all respects similar, and include a biotite bearing variety.

ACKNOWLEDGMENTS.

The writer wishes to express his gratitude to Mr. Innes and especially to Dr. Walker, for the encouragement they have given, and for the many helpful suggestions which they have offered towards the composition of this paper.

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Explanation of Microphotographs.

Ordinary Light. × 24.

1. Hypersthene Andesite. (Northfield, No. 100).

Two phenecrysts of Colourless augite, separated by a ragged area of haematite, and set in a base of felspar laths in fluidal arrangement. The base contains numerous grains of iron ore, but pyroxene is rare. Adjacent to the lower augite are two dark areas representing serpentintised hypersthenes.

2. Hypersthene Andesite. (Shore No. 16).

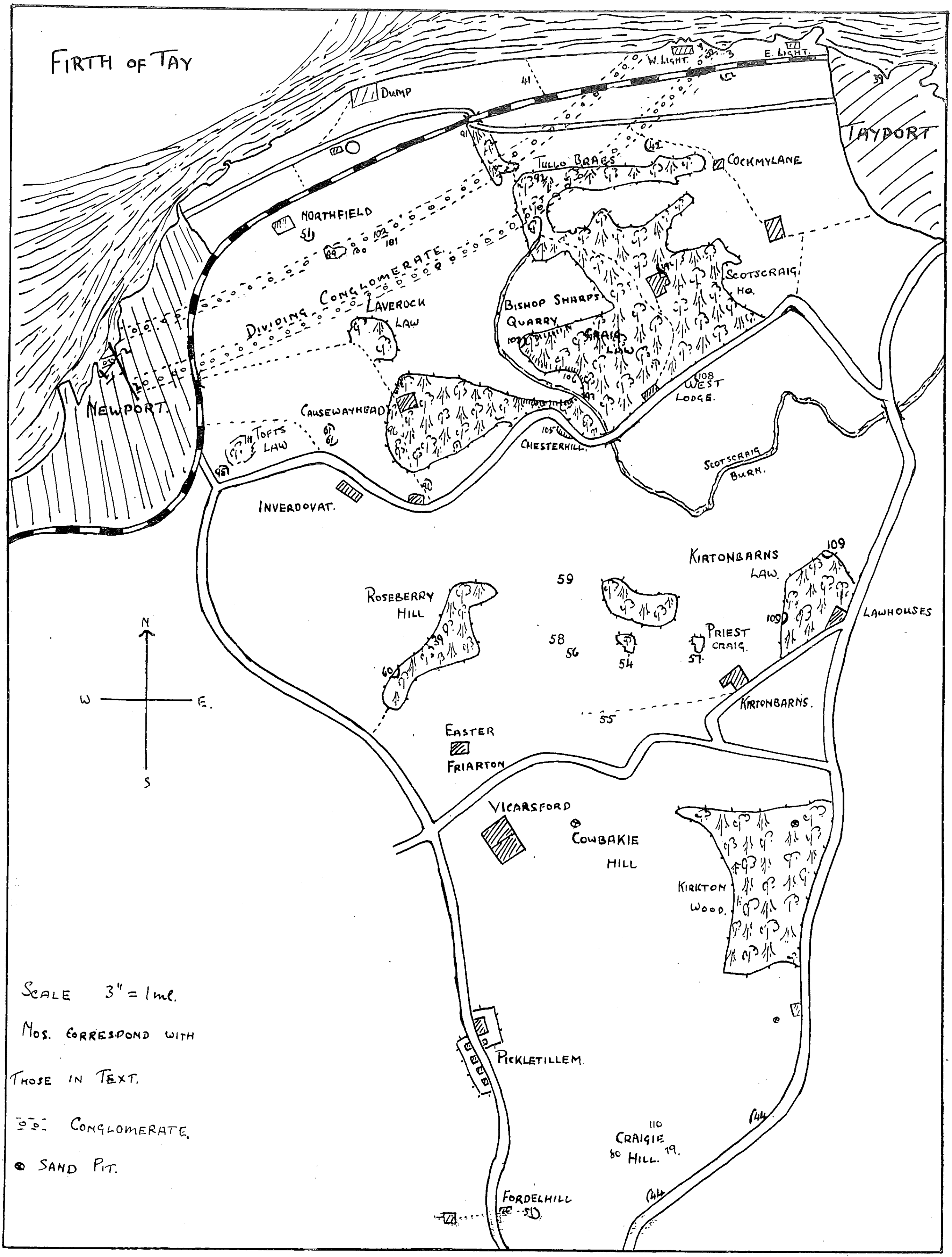
Not so highly crystalline as above; showing phenocryst of plagioclase, with ring of glassy inclusions, and two pseudomorphs after rhombic pyroxene. Plentiful iron ore represents altered ferromagnesians.

3. Hypedsthene Andesite. (Northfield No. 50.)

Similar to 1, but showing elongated phenocryst of hypersthene, only partially altered. In the field there is also a large augite and two dark areas of iron ore after pyroxene.

4. Hypersthene Andesite. (Kirktonbarns, No. 54).

Coarse grained rock with glomero-porphyritic aggregates of pyroxene and felspar with interstitial glass.



Map of old sandstone lavas at mouth of River Tay, figures referred to in text.

PLATE XX.

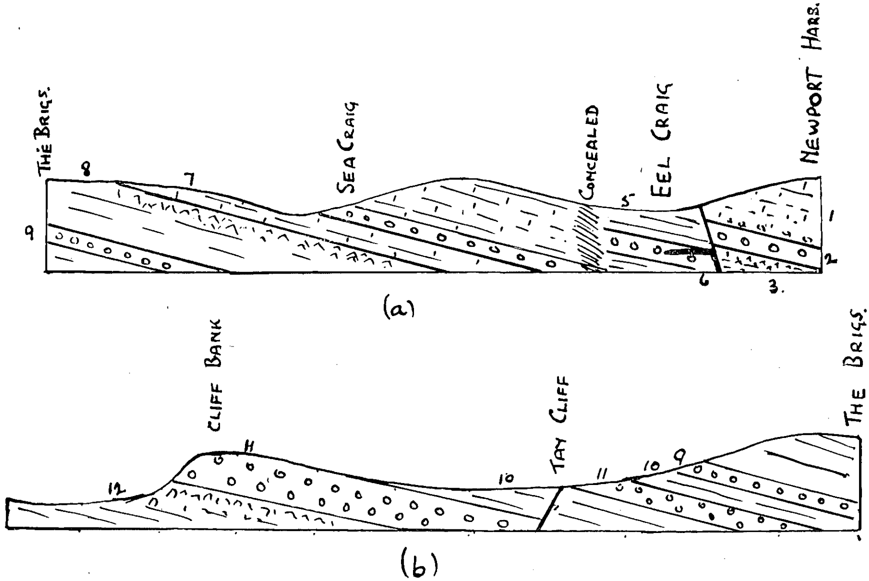


PLATE XXI.

Diagrammatic Sections Illustrating Structure on Newport Foreshore. Vertical Scale, 25″=1″. Hor. Scale exaggerated. Numbers correspond with those in text.

Andesite. Conglomerate.

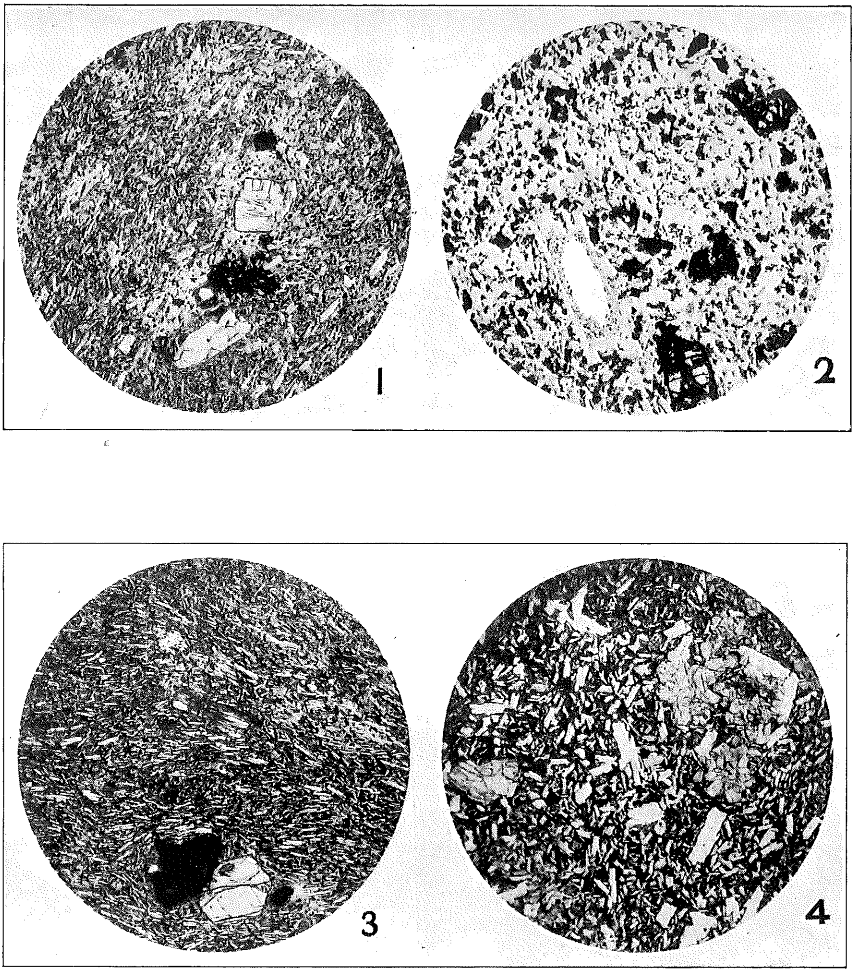


Plate XXII.

XXI.—*On* Microyoldia Regularis *Verrill, from Errol, Perthshire.*

By CHARLES F. DAVIDSON

with Plate XXVII.

(Read February 10th, 1933)

The following note is complementary to the paper by the author on the arctic clay of Errol, published in this society's Transactions (1). Subsequent to this investigation a detailed study was made of a number of minute lamellibranchs, at first regarded as *Yoldiella limatula* (Möller) = (*Nuculana tenuis* Phillippi), but later referred to the species *Microyoldia regularis* Verrill. Unfortunately, it has not been possible so far to examine the type specimen, and the identification, for which I am indebted to Mr. D. F. W. Baden Powell, has been based on Verrill's figure only.

Microyoldia regularis Verrill forms the genotype of *Microyoldia*, Verrill and Bush, 1897 (2). It is a cold North American shell of extreme rarity, closely resembling *Yoldiella limatula* (Möller), but having about half the number of teeth normal to that species. The type specimens are three " dead " shells taken in 1882 near Martha's Vineyard, an island lying off the coast of Massachusetts, lat. 41 degrees, 22' N., long. 70 degrees, 35' W., at a depth of 349 fathoms (3). Most of the Errol shells agree closely with the described New England specimens in all respects.

Dimensions.

	Length.	Height.	Height : Length.
(1)	3.5 mm.	2.5 mm.	71.4 : 100
(2)	1.92 mm.	1.47 mm.	70.6 : 100
(3)	2.57 mm.	1.82 mm.	70.8 : 100
(4)	4.00 mm.	2.90 mm.	72.5 : 100
(5)	4.70 mm.	3.51 mm.	74.4 : 100

(1) Martha's Vineyard, Massachusetts. (2)—(5) Errol, Perthshire. Measurement of Errol specimens has been made by a recording micrometer, and by the employment of such accurate methods it becomes evident that the height : length ratio is not constant, but varies directly as the age of the mollusc.

The species occurs in considerable abundance in rather peaty bands of the basal (100 foot) clay of Errol, associated mainly with *Buccinum groenlandicum* Chemnitz. In all, over 100 specimens have been obtained, these being now located in the Museum of this society, and the University Museum, Oxford.

A striking number of the complete shells from washings are punctured by a boring gastropod, presumably *Natica pallida*

Broderip and Sowerby, which occurs throughout the deposit in small numbers, but as *Buccinum groenlandicum* Chemnitz is present in much greater abundance, and more intimately associated with the *Microyoldia*, the boring might doubtfully be attributed to this species, although I am unaware of any previous reference to boring by a *Buccinum*. It is generally found that here, as elsewhere (5), the younger the lamellibranchs, the smaller are the gastropods which prey upon them, the ratio of the diameter of the holes to the size of the valves maintaining a rough constancy.

The percentage of lamellibranchs killed by either of these gastropods is obtainable from the formula :—

$$\frac{\text{Number of bored valves} \times 2}{\text{Total number of valves}} \times 100.$$

In this case the figure reaches the abnormal height of 53 per cent. High figures have also been noted by F. M. Davis (4) in the case of *Spisula subtruncata* (da Costa) in the North Sea (88 per cent.), while the death-rate in *Astarte triangularis* (Montagu) at the Eddystone reaches 48 per cent. (5). The observations taken at Errol are particularly striking, as no other micromollusc appears in the washings with evidence of boring. The larger species are too decomposed or too fragmentary for adequate recognition of this phenomenon.

Microyoldia regularis Verrill has not hitherto been noted from any of the Scottish raised beaches, and consultation of various memoirs on arctic malacology mentioned previously (1) has failed to produce notice of discovery in European arctic lands. It is, therefore, fitting that this occurrence should be placed on record.

It is also desired to register the occurrence of *Yoldiella* (= *Nuculana*) *intermedia* (M. Sars). No whole shells have been found, but numerous fragments, particularly some characteristic interlocked hinge-lines, leave no doubt as to the identity of the species.

I am indebted to Miss Helen Wallace for the accompanying plate.

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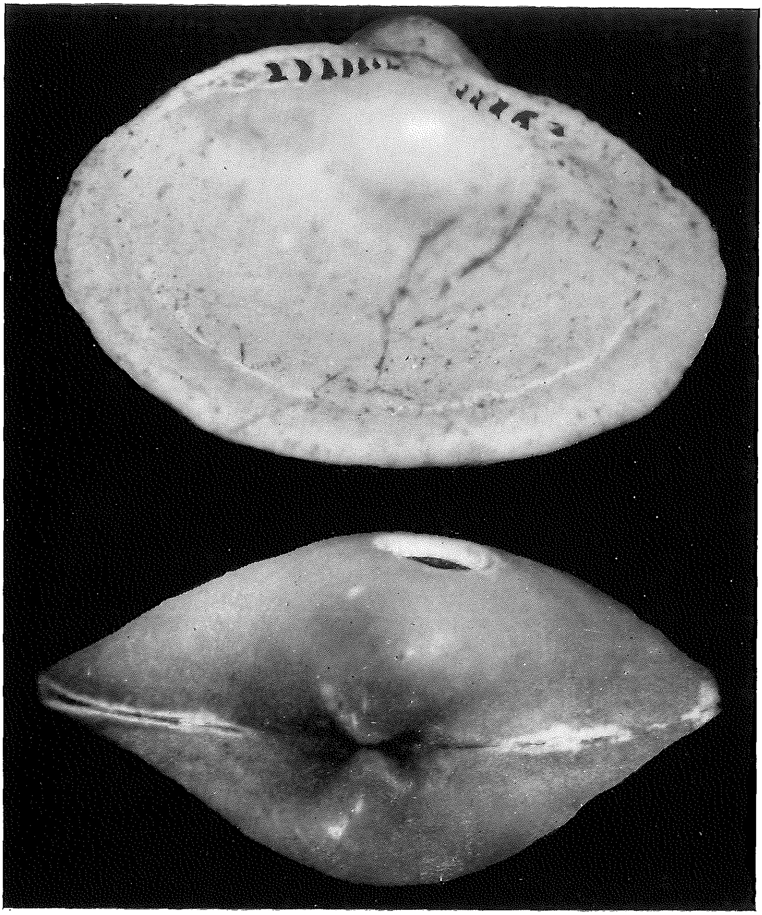


PLATE XXVII.

Microyoldia regularis, Verrill. Above, interior of left valve. Below, dorsal view of the two valves, showing boring due to a gastropod. Magnification 25 diameters.

XXII.—A Preliminary Account of the Quartz-Dolerite Dykes of Perthshire.

By FREDERICK WALKER, M.A., D.Sc.

(Read 10th February, 1933).

Plates XXVIII. and XXIX.

Two distinct suites of dykes attain a prominent position in the igneous geology of Perthshire. The first (and earlier) of these has a definite NE-SW trend, parallel to the grain of the country, being connected with the great igneous activity associated with the Caledonian movements. The second suite has a slightly less constant trend, roughly E.N.E., but swinging round occasionally to due east. This suite appears to be connected with earth movements of Carbo-Permian age, and is the one considered in the present communication. There are other dykes in the Perthshire highlands which are of earlier age than the two above suites, but they have undergone marked changes during the regional metamorphism of the district and are less worthy of detailed study. The Tertiary suite with N.W. trend, so prominent in the West of Scotland, is conspicuous by its absence in Perthshire, for the county lies outside the path of the great dyke swarms.

Previous Literature.

In his monumental work, "The Ancient Volcanoes of Great Britain,"[1] Sir Archibald Geikie gives much space to the "solitary" dykes of Tertiary age, and includes amongst these the dykes now under consideration, but no special attention is given to the Perthshire examples. The bulk of our information about them is to be derived from the work of the late Peter Macnair, who has contributed so many fine papers to the Transactions of the Society. In his important book, "The Geology and Scenery of the Grampians,"[2] he devotes a chapter to the "dolerite dykes," laying most emphasis on those of Perthshire. Both field relations and petrography are fully dealt with and his descriptions are rendered the more valuable by the inclusion of excellent photographs and photomicrographs. He followed Sir Archibald Geikie in assigning the dykes to the Tertiary igneous activity, and established clearly their doleritic nature.

In the Geological Survey Memoir of East Fife,[3] a petrological description of an E.W. dyke at Auchterarder Station is given, while brief mention of examples belonging to our suite is made

1—A. Geikie, "The Ancient Volcanoes of Great Britain," 1897, vol. 2.
2—P. Macnair, "The Geology and Scenery of the Grampians," 1908, vol. 2, chapter 12.
3—The Geology of East Fife, Mem. Geol. Survey, 1902, p. 404.

in the Memoir for Blair Atholl, Pitlochry, and Aberfeldy.[1] More recently, Dr. D. A. Allan in his important paper on the Highland Border Rocks[2] refers to the occurrence of quartz-dolerites and tholeiites of Salen type in this area, which includes a small portion of east Perthshire between the Tay and Alyth, but he gives no petrological descriptions.

In their magnetic survey of the Lornty Dyke[3] (about one mile north of Blairgowrie) Drs. M'Lintock and Phemister give a brief description of the rock of the dyke which they consider to be a tholeiite of the Brunton type.

Finally, Mr. C. F. Davidson,[4] in describing the geology of Moncreiffe Hill, comments upon the resemblance of the E.W. dykes which cut the lavas, to dykes of similar habit from other areas in Central Scotland.

Since the publication of Macnair's book in 1908, an extensive literature on the Carbo-Permian dolerite dykes of Britain has grown up. The communication is an attempt to show wherein the Carbo-Permian dolerite dykes of Perthshire resemble and differ from those of other districts.

Distribution and Field Characters.

The occurrence of the suite under consideration, that is, of dolerite dykes with a more or less easterly trend, appears to be confined to the southern portion of Perthshire, and no such dyke has yet been discovered to the north of the River Tummel. The greatest development seems to be round the town of Perth itself, where numerous examples are known.

North of the Highland Line the dykes do not form very pronounced topographic features, nor are they very prominent amongst the lavas of the Sidlaw Hills, but where they cut sedimentary strata of Lower Old Red Sandstone age they frequently stand out boldly above their surroundings. Excellent examples of this are seen at Craigmakerran (¾ mile N.E. of Guildtown), and on the Crieff-Muthill road (about one mile north of Muthill), while the dyke which crosses the River Tay at Thistlebridge shows similar features on both banks of the river. The wall-like sides of these dykes often exhibit well-exposed chilled contacts with the adjacent strata.

Other dykes in the Lower Old Red Sandstone area of Perthshire are much less prominent, and are only exposed to advantage where road-metal quarries have been opened. In these quarries the entire breadth of the dyke is generally exposed, a condition which is of great convenience to the collector.

1—The Geology of Blair Atholl, Pitlochry, and Aberfeldy, Mem. Geol. Survey, 1906, p. 131.
2—D. A. Allan, Trans. Roy. Soc. Edin., vol. 56, p. 85.
3—Mem. Geol. Survey, Summary of Progress for 1930, part 3, p. 24.
4—C. F. Davidson, Geol. Mag., 1932, p. 456.

Fine exposures are also seen at several points where dykes cross rivers, the Almond and the Tay being particularly favoured in this respect. Special attention was directed by Macnair[1] to the Linn of Campsie, where a dyke is seen to bifurcate.

Amongst the lavas and the older rocks of the Highlands road-metal quarries again form the best exposures. It is unfortunate, however, for geologists that all over the country the recent policy of centralisation has resulted in most of these quarries falling into disuse. It is thus more difficult than formerly to obtain fresh material.

The breadth of individual dykes is very often in the neighbourhood of 60 feet, but may vary within wide limits. None is very thin, while the maximum breadth recorded by the author for any dyke was at Craigmakerran where the wall-like feature is about 120 feet across. This figure is, however, far short of the 300 feet shown on the one inch geological map (sheet 48).

Some of the dykes attain a very considerable length. The southerly of the two great dykes which cross Moncreiffe Hill actually extends, with several breaks, from the neighbourhood of Loch Fyne to Newton Hill in Fife, a distance of nearly 80 miles. It is, in fact, only surpassed in length amongst British dykes by the Cleveland Dyke which is of Tertiary age. Another dyke, which passes by Auchterarder station, possibly stretches from central Cowal to Lucklaw Hill in Fife, a distance of over 80 miles, but its outcrop is less continuous. Other dykes have been traced only over quite short distances, in some cases less than a mile.

Macnair pointed out that most of the dykes show columnar jointing and that they are nearly all practically vertical, except in the immediate neighbourhood of the Highland Fault—as, for instance, the dyke between Blairgowrie and Craighall (presumably at Lornty). The horizontal columns form a conspicuous feature in many road-metal quarries, but towards the margin a set of vertical joints parallel to the contacts makes its appearance.

Nearly all the dykes under consideration are medium grained rocks which become finer and slightly vesicular towards the margin. The fresher rocks show dark grey on the freshly fractured specimen, but alteration produces a greenish tinge. Some of them darken on exposure to the atmosphere, this being due, in some cases at least, to a content of chlorophaeite.

A feature of the Perthshire dykes is the paucity of the acid veins and patches which are so conspicuous in the corresponding dykes in the Carboniferous sediments to the south. In the southernmost dykes of Perthshire, e.g., the dykes at Auchterarder Station, Friarton Hill, and Glenfarg, small acid veins may

1—Loc. cit., p. 85.

be observed, but they are never found in great abundance. The reason for this will be seen when the petrology of the dykes is considered.

Several of the dykes which traverse Perthshire contain black asaltic veins, but not always at points within the county oundaries. These basaltic veins occur in the interior of the dykes and are therefore quite distinct from the chilled margins which they resemble in appearance. They are found in dykes at Tannadice in Angus (probably the easterly extension of the Lornty dyke), at Tullymet near Ballinluig, and at Newton Hill, south of Wormit. The first two examples show veins up to 6 inches in thickness, chilled against the normal rock. It may be noted at this point that the Newton Hill dyke is unrecorded on any of the published maps.

The contacts, where visible, are usually chilled, but the selvages seem peculiarly prone to decomposition and are never preserved in a fresh state. Beyond hardening and slight colour change the country rock, whether it be igneous, sedimentary, or metamorphic, seldom shows many striking signs of contact alteration. Interesting types of hornfels have, however, been described adjacent to the dyke at Corsiehill quarry, near Perth.

Age of Dykes.

Sir Archibald Geikie considered that all the great "solitary dykes," as he called them, of the Midland Valley and Southern Highlands belonged to the Tertiary epoch of igneous activity. He, therefore, grouped the E.W. suite, which we are considering, with the true Tertiary examples which have a dominant N.W. S.E. trend. Nevertheless, he recognised that the former suite was the earlier, for the work of C. T. Clough in Cowal[1] had proved this to be beyond dispute. In this grouping he was followed by Macnair, but in recent years much fresh evidence has come to light.

It is now thought by most petrologists that the E.W. dykes of Perthshire belong to a great E.W. dyke suite extending from south Banffshire to the River Tees. These dykes are considered to be co-magmatic with the Whin Sill with which many of them are identical in their chemical composition and petrographic characters. Their E.W. trend is due to a change of the dominant structural lines of the country from a N.E.-S.W. direction (set up in Caledonian times) to an E.W. direction during the Hercynian earth movements.

In the Midland Valley the dykes (and sills which branch off from them) are in some cases older than the faulting and folding and in some cases younger, while both dykes and sills cut all strata up to and including Coal Measures. Thus the age of the

1—The Geology of Cowal, Mem. Geol. Survey, 1897, p. 140.

suite as a whole is thought to be Carbo-Permian. Important confirmatory evidence of this in north England has been added by Professor A. Holmes,[1] who discovered a pebble of rock identical to that of the Whin Sill in the Permian Brockram of the Eden Valley. It has also been shown that the Whin Sill was affected by the mineralisation which took place in Carbo-Permian times. Thus it may be stated with a certain degree of probability that the Perthshire dykes are also of Carbo-Permian age, although they are not seen to cut strata younger than the Lower Old Red Sandstone. The age of the faults of Perthshire is doubtful, but in nearly all cases the dykes seem to be unaffected by them.

Petrology.

Microscopical examination of the dyke suite reveals two interesting features which do not appear to have been recorded previously. First, the great majority of the dykes under consideration carry a considerable amount of glassy mesostasis, and are therefore of tholeiitic character, and second, the widespread occurrence of serpentinous pseudomorphs after olivine or rhombic pyroxene in the tholeiites.

The absence of micropegmatite from all but a very few of the Perthshire dykes serves to differentiate them from the true quartz-dolerites which occur in such abundance in the Carboniferous strata of the Central Valley of Scotland and the North of England. There seems to have been an inhibition upon the crystallisation of quartz and alkali felspar in the Perthshire dykes which accounts both for the occurrence of a glassy mesostasis and for the corresponding absence of micro-crystalline acid segregations. It is, perhaps, too early to discuss the reasons for the inhibition, but in the opinion of the writer it is connected with the distribution of volatile constituents in the magma.

The Perthshire dykes of E.W. trend may thus be divided primarily into quartz-dolerites and tholeiites.

Quartz-dolerites.

The dykes in the neighbourhood of Auchterarder, Glenfarg and Moncreiffe Hill appear to be true quartz-dolerites containing thin segregation veins of felsitic appearance. In nearly all slides, however, the micropegmatite has weathered to reddish-brown decomposition products and is no longer recognisable. The dyke which was quarried at Auchterarder Station is a conspicuous exception and worthy of detailed description since all its constituents are well-preserved. It was identified by Professor H. W. Seymour[2] as an olivine-dolerite in which the rare olivine crystals had been serpentinised, but his description is evidently based on the examination of weathered material. Fresh specimens

1—A. Holmes, Min. Mag., vol. 21, 1928, pp.531-3.
2—The Geology of East Fife, Mem. Geol. Survey, 1902, p. 104.

are obtainable from all but the marginal portions of the dyke and prove it to be quartz-dolerite of typical Whin Sill type.

The two most abundant constituents of the rock are plagioclase and monoclinic pyroxene. Of these, the former occurs as elongated laths measuring on an average about 1mm by 0.25mm. It is strongly zonal, but the central portions appear to consist of medium labradorite in most cases. Twinning on both the Carlsbad and albite laws is the rule, while pericline twinning is rare. This felspar occurs in sub-ophitic relationship with a pale brown monoclinic pyroxene which may form isolated crystals or groups. It has a large axial angle (usually about 60°) which serves to distinguish it from another monoclinic pyroxene of prismatic habit which is distinctly more idiomorphic. This prismatic pyroxene has a low axial angle and sometimes shows incipient alteration to serpentine. It is much less common than the sub-ophitic variety. Hypersthene is also a minor constituent of the rock, forming rare idiomorphic prismatic crystals which show faint pleochroism and partial alteration to bastite. Brown hornblende is sometimes seen as a marginal intergrowth on the sub-ophitic pyroxene, and biotite is of sparse occurrence, being most abundant in the neighbourhood of the iron ore (titanomagnetite or ilmenite in irregular crystals). The interspaces between the plagioclase crystals are frequently occupied by a fine micrographic intergrowth of quartz and orthoclase, but patches of secondary calcite are also to be observed. With the occasional exception of hypersthene, all the minerals of the rock are in excellent preservation.

The rock is traversed in parts by thin veins of aplitic composition consisting of small crystals (0.05mm) of quartz and alkali felspar (often in micrographic intergrowth) with small scraps of iron ore and chlorite.

In the normal rock the mode is approximately :—

Monoclinic pyroxene	30
Hypersthene	2
Hornblene and biotite	1
Iron ore	6.5
Plagioclase	56
Micropegmatite	3
Apatite	0.5
Calcite	1

The above mineral assemblage is in good accord with the average rock of the Whin Sill, and serves to bring out the close petrological resemblance between the holocrystalline E.W. dykes of Perthshire and the great sheet of the North of England. The resemblance is emphasized by direct comparison of slices under the microscope, which shows that not only the mineral assemblage but also the optical properties of the minerals themselves are the same for the rocks of both areas. It is true that the Auchterarder dyke is the only true quartz-dolerite in Perthshire in really good preservation, but the others, though altered, exhibit the same features, varied only by slight changes in grain, the texture as a rule being somewhat coarser.

Tholeiites.

The tholeiite dykes are much more varied in type than the quartz-dolerites. They are, on the whole, fresher rocks and in most cases the felspar is absolutely unaltered. The finer varieties which occur towards the margins of the dykes are, however, more decomposed, while the same may be said of the black basaltic veins which occur in some examples. In the hand specimen the coarser rocks show numerous sparkling crystal faces—a feature absent from the more decomposed of the quartz-dolerites. The absence of light-coloured segregation veins, and the darkening on exposure to the atmosphere are characteristics which have already been mentioned. In one or two isolated cases, however, even these criteria fail to place the rock in one group or the other, but this is only the case when decomposition is more advanced than usual.

Corsiehill Type.[1]—One of the freshest rocks in the suite is that of the E.W. dyke which is quarried at Corsiehill, near Perth. The central portion of this dyke consists of a distinctly coarse dark rock with a lustrous appearance in the hand specimen.

Under the microscope it is seen to be composed essentially of unaltered plagioclase and pale brown sub-ophitic augite, the felspar being a medium labradorite as in the quartz-dolerites, while the pyroxene has an axial angle of about 60, and an extinction angle of 43°. Serpentinous pseudomorphs, apparently after rhombic pyroxene (or possibly olivine), are common, as large crystals of skeletal ilmenite. Minor constituents are sparse interstitial brown glass (usually containing crystallites and partially devitrified), and a little secondary quartz and chlorite. The rock is even-grained and coarse, the felspars measuring up to 2mm in length. It is distinctly richer in pyroxene than the normal quartz-dolerites, and the approximate mode is :—

Augite	36
Hypersthene (serpentine)	6
Iron ore	4
Mesostasis	2.5
Apatite	0.5

Rocks very similar to the normal Corsiehill type are seen in the N.E. dyke at Linn of Campsie, at Pitroddie Quarry, at Newmiln (Guildtown), at Fowlis Wester (4 miles E.N.E. of Crieff, at Tullymet (Ballinluig), at Dalguise, at Lawers Burn Quarry (Loch Tay), at Achmore Quarry (Killin), S.W. of Craig Uigeach (Glen Lednock), at Lechkin Quarry (Comrie), at the bridge over the

1—The type names given are for convenience of reference in this paper and are not intended for general application.

Fillan Water 1½ miles below Tyndrum, and in the dyke exposed by the new road cutting 2 miles east of Dalmally. None of these examples is quite so fresh as the Corsiehill rock, and some of them contain a little more mesostasis.

Craigmakerran Type.—Another fairly distinct type is that found in the central portion of the Craigmakerran dyke. It is slightly finer in grain than the Corsiehill rock, and the felspars are more slender, though they may attain a length of 2mm. The same constituent minerals with identical optical properties are present, but the proportion of modal pyroxene has dwindled to about 35%, while at least 10% of mesostasis is to be found. This mesostasis is quite decomposed, but appears to have been a microlitic glass. Otherwise the rock is in good preservation, although the sparse rhombic pyroxene (or olivine) is invariably serpentinised.

Dykes of this type were found at Campsie Linn (E-W dyke), at Pass of Leny (Callander), and at Loch Clunie Quarry. The amount of mesostasis is variable, and in some cases, notably at the Pass of Leny, it is variolitic.

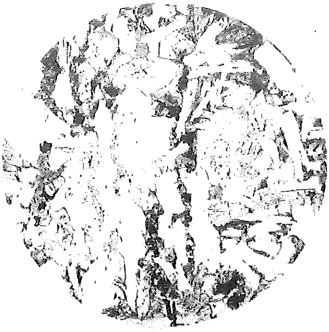
The vast majority of the tholeiites fall into the Corsiehill and Craigmakerran groups with only very slight variation, but the dyke at Lornty (Blairgowrie) is exceptional. The mineral composition of the rock agrees well with the Craigmakerran type, but the texture is porphyritic, plagioclase forming distinct phenocrysts up to 2.5mm in length. This rock has been referred to the Brunton type of tholeiite by Drs. M'Lintock and Phemister.[1] The description given, however, shows poor agreement with that of the type example or with its published figures. Both the porphyritic character and the lack of aggregation of the constituents seem to preclude the reference of the Lornty rock to the very constant Brunton type.

Basalt Veins.—There remain only the marginal modifications and basaltic veins to be considered.

In most cases the fine-grained margins of the dykes are thoroughly decomposed, though they may retain a black colour in the hand specimen. The marginal portion of the E-W dyke at Linn of Campsie takes on the character of a porphyritic basalt, the groundmass becoming increasingly finer towards the contact. This groundmass, when it is sufficiently coarse to be determined, consists of magnetite, augite granules, and plagioclase. Quartzose vesicles are occasionally a conspicuous constituent.

Two fine-grained rocks from Glen Tarken (Loch Earn) and Lochearnhead are worthy of attention. The first resembles the Craigmakerran type in mineralogical composition and texture, but the plagioclase crystals are not more than 0.4mm in length. The second rock is slightly coarser and consists of

1—loc. cit.



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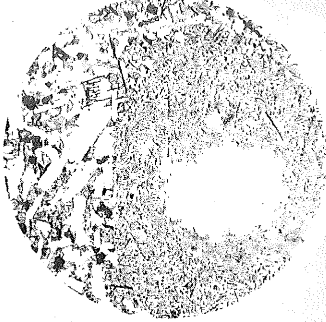

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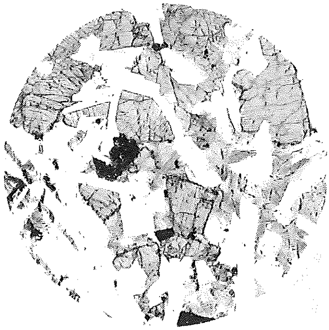

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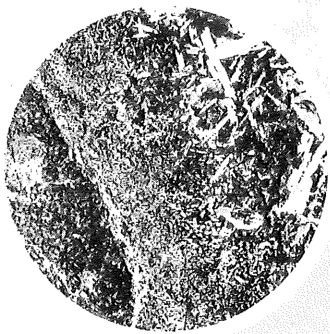

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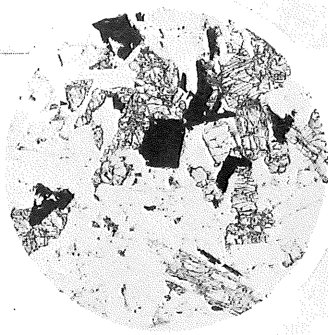

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Plate XXVIII.

Fig. 1—Tholeiite, centre of dyke, Craigmakerran; × 13 diameters, ordinary light. Somewhat finer in grain than the Corsiehill type, and contains more mesostasis.

Fig. 2—Tholeiite, centre of dyke, on Newton Hill, Wormit; × 13 diameters, ordinary light. Resembles the Craigmakerran rock, but contains a glass-filled vesicle with a centre of quartz and calcite.

Fig. 3—Tholeiite, centre of dyke, Corsiehill Quarry; × 13 diameters, ordinary light. Large crystals of labradorite and augite are seen in sub-ophitic relationship. Iron ore is prominent and a little interstitial mesostasis may be observed.

Fig. 4—Basaltic vein, centre of dyke, in river at Tannadice; × 13 diameters, ordinary light. Porphyritic labradorite is conspicuous in a black indeterminate groundmass.

Fig. 5—Quartz-dolerite, centre of dyke, Auchterarder Station; × 13 diameters, ordinary light. Labradorite and augite are seen sub-ophitic relationship, and one or two well-formed crystals of hypersthene show serpentinisation along cracks. Iron ore is conspicuous.

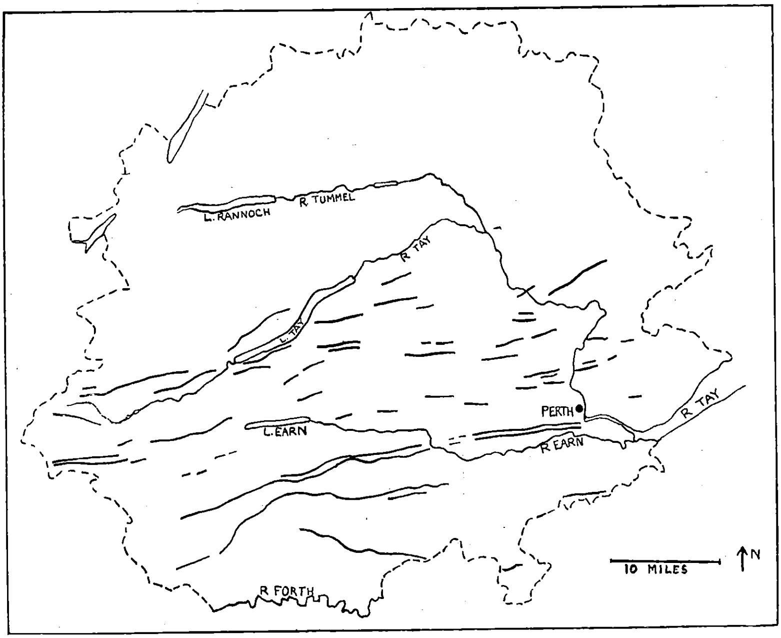


PLATE XXIX.
Sketch-Map showing distribution of quartz-dolerite dykes in Perthshire.

fresh labradorite laths and intersertal augite of the usual colour embedded in an abundant dark green base of what appears to be palagonite. Further examination of this curious type seems indicated.

The basaltic veins which occur in the dyke of Tullymet, and outwith our district at Tannadice and Newton Hill near Wormit, strongly resemble the marginal modifications just described. The vein which occurs in the centre of the Tannadice dyke is almost identical with a slide made of a specimen labelled "Wolf-hill" (3 miles east of Stanley Station). These rocks carry phenocrysts of labradorite and decomposed ferromagnesian minerals in a very fine-grained groundmass in which magnetite is conspicuous. At Tullymet and Newton Hill the veins are distinctly coarser in texture, though still basaltic. Chilling of the basalt veins against the normal tholeiite is beautifully seen in slides from Tullymet and Tannadice.

In the course of investigating the tholeiites, the author found great difficulty in determining whether the serpentinous pseudomorphs present in almost all these rocks were after hypersthene or olivine. Many cases must remain doubtful, but in general the conclusion was reached that hypersthene is typical of the coarser varieties and olivine of the finer. In the case of one coarse tholeiite from Melville Monument (Comrie), a scrap of fresh hypersthene remained in one of the pseudomorphs, which lends a certain amount of support to the above conclusion. No fresh olivine was, however, detected in any slice.

General Conclusions.

In Perthshire the E-W dykes are mainly of the tholeiitic type, quartz-dolerites being relatively scarce and confined to the south or lowland part of the county. It is unlikely that there is much difference in chemical composition between the quartz-dolerites of Whin Sill type and the tholeiites, though some variation does occur, and the latter group appears to be slightly more mafic on the whole. This may possibly be due to a concentration of resurgent volatile constituents in the lowland dykes which are, perhaps, exposed at higher positions. Acid segregations are certainly more conspicuous in the sill phase developed farther south in the Central Valley, and it may well be the case that we are dealing there with the topmost, and therefore the most felsic, phase of the suite. Such suggestions are, however, purely hypothetical and best kept apart from the known facts which are summarised in the first two sentences of this paragraph.

Acknowledgment.

Throughout this investigation the author has received most valuable assistance from Mr. John Ritchie, who has very kindly given him access to material in Perth Museum. Of this assistance and the encouragement which has accompanied it, he hopes to avail himself further when the work is carried nearer completion.

XXIII.—*Antiquarian Finds from Tentsmuir and District.*

By HELEN M. WALLACE.

(Taken as read 9th February, 1934).

Plates XXX., XXXI. and XXXII.

In the Transactions of the Perthshire Society of Natural Science, Volume VIII., Part V., 1927-28, a paper was published by Mr. Ritchie on a collection of antiquarian finds from Tentsmuir. The collector, Mr. Arthur G. Wilson, has since then added a large number of axe-heads, flints, arrow heads, whorls, scrapers, beads, amber and jet fragments from the same locality, the most interesting of which are briefly described in the following communication. A considerable number of implements from the same collection have been found at Clunie Farm, Newburgh.

Figure No. 1 (Plate XXX.) is an amulet of sandstone, 8 cms. long, 4.5 cms. at head, broadening to 6 cms. at base, and 1.7 cms. in thickness, which in all probability was hung at a doorway as a charm to ward off evil spirits. At the head a biconical circular hole, 2.2 cms. in diameter, has been drilled.

Figures 2 and 3 (Plate XXX.) and another specimen somewhat larger than number 2, illustrate hammer stones of schist. Number 3 has been split through the centre. They are round at the base coming to an oval shape at the head, with a cup-like depression in the centre of the back and front for the finger and thumb to grip. The measurements of the largest one are 12 cms. long, 9.5 cms. broad, 3.3 cms. thick, and depth of hollow 1 cm. Number 2 is 10 cms. long, 7.5 cms. broad, varying from 4.25 to 4.5 cms. thick, depth of hollow 1 cm. Number 3 is 9.5 cms. long, 3.6 cms. broad, 5.1 cms. thick at base and 3 cms. at head, depth of hollow 1 cm. Number 2 was found at Clunie Farm, Newburgh, and the other two stone hammers were obtained at Garpit Farm, Tentsmuir.

Number 6 (Plate XXX.) found at Garpit in March, 1931, is a stone axe head of schist which measures 8.2 cms. in length, 6.2 cms. in breadth, and 3 cms. in thickness.

Numbers 4, 5 and 11 (Plate XXX.) are implements of banded greenstone. Number 4, an axe head from Clunie Farm, is 9 cms. long, 5 cms. broad and 3.2 cms. thick. Number 5, a hammerstone slightly bevelled on one side and almost flat with a slight fracture on the other side, is 11 cms. long, 4.1 cms. broad and 2.5 cms. thick. Number 11 is part of an axe-head found at Garpit in 1930. It is 4.5 cms. long, 5.6 cms. broad and 2.25 cms. thick.

Number 7 is a polisher of greenstone from Garpit, measuring 9.75 cms. in length, 4.25 cms. in breadth and 3.5 cms. in thickness.

Figure 10 illustrates a piece of jet from Commerton measuring 6 cms. in length, 6.1 cms. in breadth, 1.75 cms. in thickness, and weighing 37 gms.

The numerous flint implements described from Tentsmuir were doubtless manufactured by the early inhabitants from flint nodules occurring abundantly on local beaches and in boulder clays. In some cases agates derived from the local Old Red Sandstone lavas were also used; there is no difference in craftsmanship between the arrow-heads of agate and those of flint.

Figure 2 (Plate XXXI.) is a flint arrow-head, with a black mark on two of the fangs.

Figures 6, 7, 8, 10, 11, 14, 15 and 16 (Plate XXXI.) illustrate flint scrapers and arrow-heads from Tentsmuir.

Figure 9 (Plate XXXI.) is a biconical drilled whorl, almost circular in shape. It measures 4.2 cms. in length, 4.4 cms. in breadth and 1.5 cms. in thickness. This whorl was found at Clunie Farm, Newburgh.

Number 13 (Plate XXXI.) illustrates a fragment of jet amulet measuring 3.8 cms. in length, 0.7 cm. in breadth, 1 cm. in thickness and weighing 2.8 gms. It has a hole bored through it near one end.

Figure 17 is a fragment of a polished edge tool, resembling calcined flint and similar in character to the round-edged polished flint previously described by Mr. Ritchie.

Figure 18 is a piece of a bronze pin, measuring 2.1 cms. in length and 0.2 cm. in breadth.

Number 19 (Plate XXXI.) is a bronze leaf-shaped point, measuring 2.4 cms. in length, 0.7 cm. broad at head and 0.2 cm. at point.

BEADS.

Five amber beads were discovered at Garpit Farm, Tentsmuir, all, except the most irregular, being found in a straight line, 200 yards long. The beads are cylindrical, three specimens being pale yellow and two distinctly reddish.

Bead.	Diameter. cms.	Thickness. cms.	Weight. gms.	Colour.
1	1.5	0.7	1.03	Pale Yellow.
2	0.75	0.5	0.57	Reddish.
3	1	1	0.27	Reddish.
4	0.85	0.5	0.18	Pale Yellow.
5	0.8	0.5	0.21	Pale Yellow.

Amber beads on the East coast of Scotland are said to have been popular among the fishing people on account of the luck and charm supposed to be in the amber. They were also worn as a protection against evil spirits, amber having the power to drive away witches and to cure blindness or other diseases of the eye.

A small bead, from Balgay, Dundee, is recorded in the Sturrock Collection. (Cat. Nat. Mus. Antiq. Scot., p. 217, 1892).

Prof. M. Heddle, in " Mineralogy of Scotland," Vol. II., page 187 (1st edition 1901, reprinted edition, 1924) notes : " Rolled specimens (of amber) have been picked up both upon the East and West Sands near St. Andrews and on the shores between " Ferry-Port-on-Craig " and Newport."

Two faience beads found at Garpit are illustrated in Figs. 6 and 7 (Plate XXXII.). Number 6 is a small, circular example, weighing 0.36 gm. and measuring 0.5 cm. in length and 0.7 cm. in breadth. It is bluish-white in colour. Number 7 is a spindle-shaped bead with a hole drilled lengthwise and shows a peculiar transverse blue and white banding. It weighs 0.47 gm. and measures 1.2 cms. in length and 0.6 cms. in breadth.

An Ilford Infra-Red Plate, with filter, was used to photograph the amber and faience beads illustrated in (Plate XXXII.).

The above notes will give an idea of the variety of articles that have been found on Tentsmuir. A large number of flint nodules, scrapers, quartz and flint chips have also been discovered, but the interest of these does not warrant description.

Museum Notes.

Figure 1 (Plate XXXI.). This flint " strike-a-light " was found in a bronze age cist at Meikleour in August, 1933.

Figures 3, 4 and 11 (Plate XXXI.) illustrate respectively two flint arrow-heads and a flint scraper, found in a field adjoining the lunatic department of the Perth Penetentiary.

Figure 5 (Plate XXXI.). A spindle whorl, found at Gannochy Edge, Perth, in April, 1933, which differs from whorl (No. 9 XXXI.) in having a straight rather than biconical boring. It measures 3.7 cms. in length, 3.8 cms. in breadth and 1.3 cms. in thickness. The diameter of the drilled hole is 1.1 cms.

Figure 8 (Plate XXX.). This stone axe of banded greenstone which was found in Blairgowrie in May, 1932, measures 11 cms. in length, 6.2 cms. in breadth and 2.9 cms. in thickness.

Figure 9 (Plate XXX.). A stone axe of greenstone, measuring 8.1 cms. in length, 5.6 cms. in breadth and 2.3 cms. in thickness, was found near Methven about thirty years ago. It was used in recent times for cleaning a stone window sill, giving rise to a false bevel.

Figure 8 (Plate XXXII.) illustrates a brass street trading badge, and bears the Perth Coat-of-Arms. The following inscription is also on it, CORPORATION OF PERTH 126 STREET TRADING. It was issued under the Children's Act of 1903, but was only used in Perth until 1918. A strap was attached to the badge, worn on the arm by children who had to earn a living by selling papers, but were under the age for leaving school.

At the same time as the Children's badge was in use, a Porter's Badge was issued. It is similiar in size and character and has " Porter's Badge " inscribed on it. It was attached to a leather strap and fastened to the front of the jacket. The eight badges

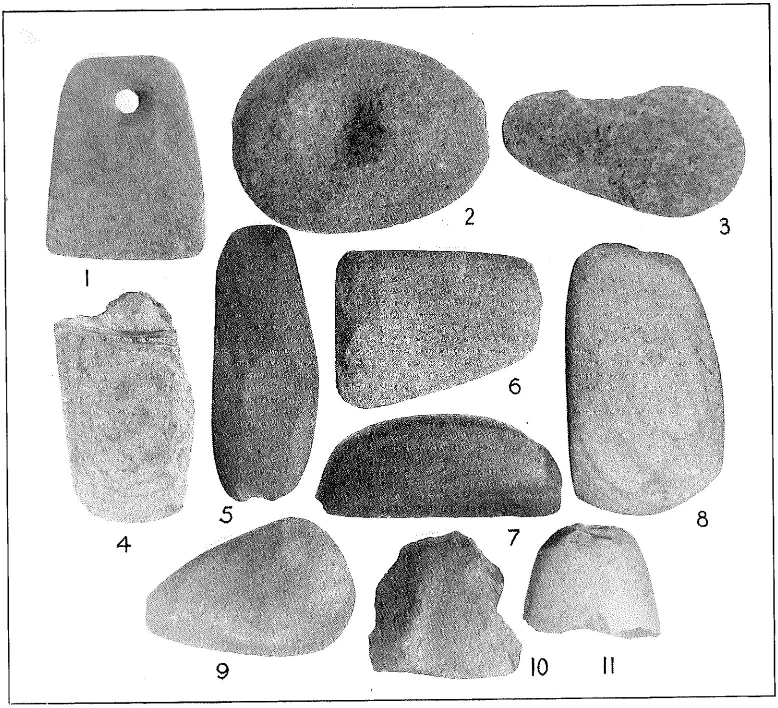


PLATE XXX.

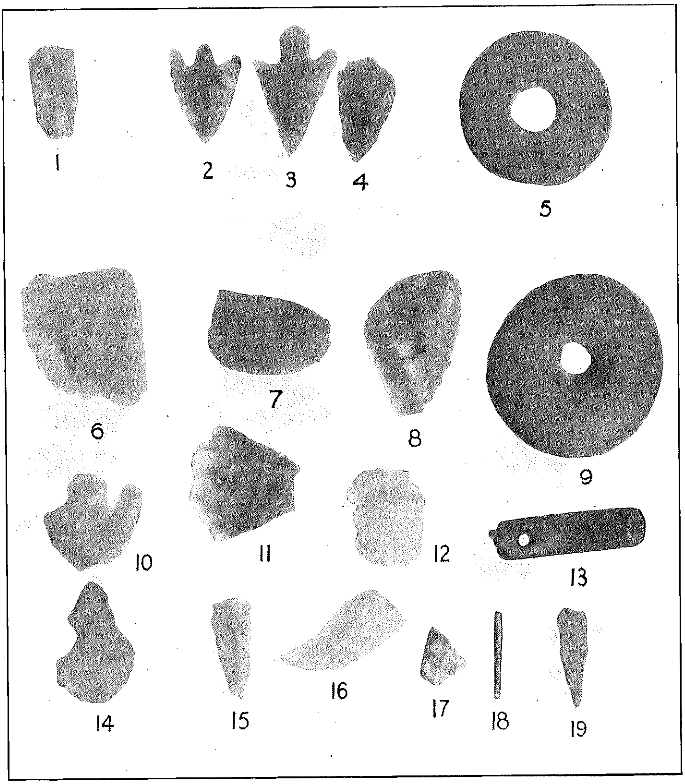
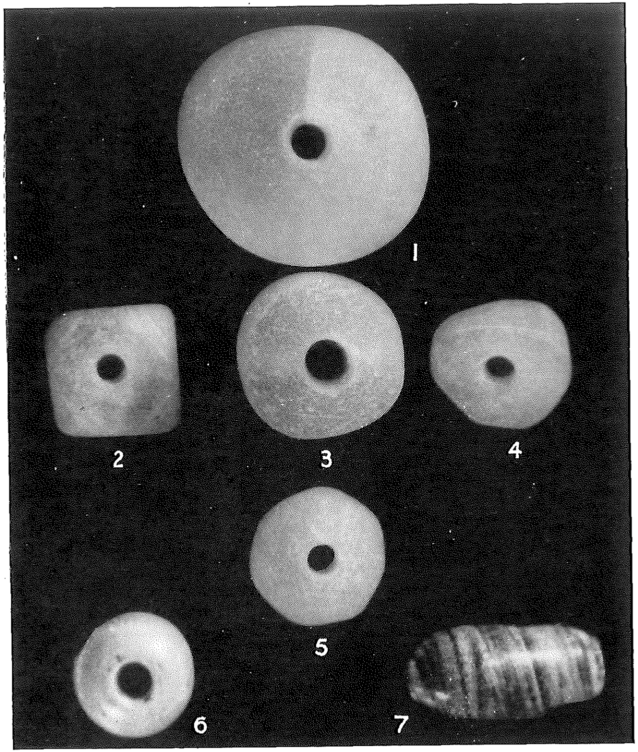


PLATE XXXI.



8

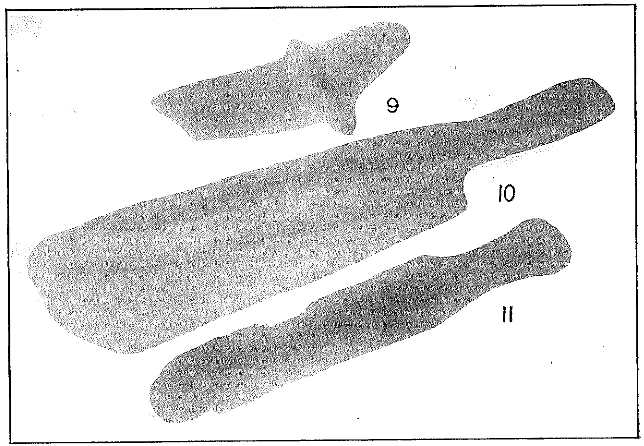


PLATE XXXII.

that were issued have all been returned and are no longer used in Perth. The information regarding both badges was received from the Chief Constable.

During the demolition at Castle Gable and excavations at site of New Museum and Art Gallery, although most of the ground was made up soil, very few finds were made, the street-trading badge, a glazed earthenware jar and several old coins being the most interesting. Two of the coins are base metal, known as Lion or Hardheads. They are penny pieces of Mary Queen of Scots (valued at 1/12th of the English Penny). Both coins were struck in Edinburgh, the smaller in 1554 and the larger between 1559-60. The small coin was found beside the earthenware jar about eight feet below the surface.

Figure 9 (Plate XXXII.). This is a coulter of mica schist which was found in the Blairgowrie district and left in the museum about four years ago. It would be attached to the front of the plough to make the furrow when ploughing. It is broken at the point and measures 29.85 cms. in length, 12.07 cms. in breadth and 5.08 cms. in thickness.

Figure 10 illustrates another coulter found in the Blairgowrie district. One edge forms a blade and the other a ledge which would allow the earth to run back and form a furrow. It measures 61 cms. in length, 15.24 cms. broad at base and 9.5 cms. at top of blade. The average thickness of the blade is 2.54 cms. and of the ledge and handle, 5.08 cms.

Figure 11. (Plate XXXII.). The use which can be ascribed to this is rather obscure. It is a water-worn stone of mica schist and was found at Glen Lyon. The date 1714 is inscribed on it and as it had been in a Glen Lyon family for three generations it was probably put to some domestic use. It is shaped for the hand to grasp at the top and the surface, of which one side is flat, has a greasy appearance. It measures 45.09 cms. in length, 6.9 cms in breadth and a general thickness of 2 cms.

XXIV.—Notes on the Distribution of some Perthshire Molluscs.

By A. Rodger Waterston.

(Taken as read, February 10th, 1933).

Three recent visits to Perthshire have been responsible for the addition of two molluscs new to the county list and for the extension of the recorded range of several others. The first visit, in July, 1931, was of short duration, when Mr. D. K. Kevan and I examined a number of lacustrine marshes in the Trossachs and Crianlarich district. Later, a month's holiday at Balquhidder in August, 1932, with Mr. J. E. Forrest, enabled us to study the marsh and lake faunas of that area in more detail, while the month of September, 1932, was spent at Birnam, where many of the neighbouring lochs and woods were examined for molluscs.

The author is much indebted to the above mentioned gentlemen for their company in the field (two pairs of eyes always produce more species than one), and to Professor A. E. Boycott for examining the shells and confirming the identification of the various species.

The mollusca of Perthshire have already received adequate treatment in an excellent paper by Coates(1) and so only the new records will be noted here.

Limax cinereoniger (Wolf).—A single juvenile example was collected in Drumbouie Woods (20/9/32, Perth E.) near the Loch of the Lowes. It was found under the bark of a dead birch, prostrated by *Polyporus*; associated with it were *L. tenellus, L. arborum, G. rotundatus, R. radiatula* and *O. alliarius.*

Zonitoides nitidus (Müll.).—This marsh species was taken on two occasions in Perth Mid., on July 23rd, 1931. Several specimens collected in a bed of *Juncus communis* at the south-west end of Loch Tay were associated with *E. fulvus, Vert. lilljeborgi, Car. minimum,* and *L. truncatula,* and later a few specimens were collected by pond-net in flooded marsh at the west end of Loch Dochart.

Vertigo antivertigo (Drap.).—This is a rare mollusc in our Scottish inland marshes. It was taken at the Mill Dam near Birnam (Perth Mid., 2/9/32), in beds of *Juncus* and *Carex,* but was by no means common. Associated with it were a few *R. pura, P. pygmaeum, Vert. lilljeborgi, S. pfeifferi* var. *brevispirata, Car. minimum, L. pereger,* and *Agr. laevis.*

Vertigo substriata (Jeff.).—Two specimens of this small species were found in moist *Nardus* pasture near Loch Ordie (Perth E., 2/9/32), on the left bank of the effluent stream at an altitude of over 900 feet. Associated molluscs were, *P. pygmaeum, Coch. lubrica, Vit. pellucida, Agr. laevis, A. ater, A. minimus,* and *Car. minimum.*

Vertigo lilljeborgi (West.).—This species, which is new to the Perthshire list, was first collected at Loch Lubnaig (Perth, W.) by Kevan and me in July, 1931. It was formerly considered to be confined to a few lake margins of west Ireland, but is now known to be widely distributed in Scotland. In Perthshire it is widespread, occurring, often in abundance, along the marshy margins of the larger lakes and rivers in all divisions of the county. A full account of its habitat and habits has already been published elsewhere(2), but for the sake of convenience, the localities in Perthshire from which I have specimens are given here (those which are dated are not included in the paper cited above).

Perth Mid. :—Loch Dochart ; Loch Tay ; Loch Lairig Eala in Glen Ogle ; Lochearnhead, by Kendrum Burn (15/8/32) ; and Mill Dam, near Birnam (2/9/32).

Perth West :—Loch Voil ; marshes by River Balvag, at Auchtoo (17/8/32) ; Strathyre, by River Balvag ; Loch Lubnaig ; Loch Achray ; Loch Chon.

Perth East :—Craiglush Loch, marshes at north-west end (1/9/32) ; and Clunie Loch, near Blairgowrie, in marshes at south end of main arm of loch, close to road (11/9/32).

V. lilljeborgi in many instances appears to replace *V. antivertigo* in the inland marsh habitat.

The usual marsh associates are *Agr. laevis*, *Car. minimum*, *E. fulvus*, *P. pygmaeum*, *S. pfeifferi* var. *brevispirata* with sometimes *L. truncatula*, *L. pereger*, or *Z. nitidus*.

Limnaea auricularia (Linn.).—Several juveniles, all referable to the variety *acuta* (Jeff.), were taken on *Apium inundatum* and *Scirpus fluitans* in the Stare Dam, near Birnam (Perth Mid., 2/9/32). Associated molluscs were *L. pereger* and *Pl. albus*.

This species is also new to the Perthshire list of molluscs and is a lowland snail inhabiting weedy lakes and canals. The variety *acuta* is the only form met with in Scotland and has a smaller and more acuminate shell than the type.

Limnaea burnetti (Ald.).—The record of this species for Perthshire seems to have been accepted without comment now for a number of years. On the 1st and 20th September, 1932, I visited the Loch of the Lowes (Perth E.) to see whether the species still existed in that locality. On the first occasion I found five specimens of a small ovate, shortspired *L. pereger*, which to me seemed nothing else than the variety *lacustris* of that species. There was no sign of any *Limnaea* resembling *burnetti*. On the second occasion I found a single dead shell of *L. pereger* var. *lacustris*. An examination of the lochs feeding, or fed by, the Loch of the Lowes produced a similar result. Spired *pereger* was found in Craiglush Loch, Butterston Loch, and Clunie Loch, all of which lie between 328 and 315 feet above sea level. Loch Ordie (1,000 feet), on a different watershed also had spired *pereger*.

The record for *L. burnetti* in Perthshire is based on a *single* shell collected by the late Buchanan-White in 1882. Mr. Ritchie, Curator of the Perth Museum, kindly let me examine the shell when in Perth on September 19th, 1932. The shell is bleached and has the spire broken and somewhat resembles *burnetti*, but so also would a specimen of *pereger* var. *lacustris* in such a state. The existing shell, therefore, is very unsatisfactory evidence of the occurence of *burnetti* in Perthshire.

Furthermore, the habitat in Perth E. is quite unlike that of *burnetti* in Loch Skene in Dumfriesshire.

The Loch of the Lowes is a typical lowland loch, whereas Loch Skene, and, indeed, all the lochs containing extreme lake forms of *pereger* (i.e. *involuta* and *praetenuis*) are lochs of the bleak highland type. Spired *pereger* does not co-exist with any of these forms. It is possible, though unlikely, that conditions have changed in the Loch of the Lowes since 1882.

In view of the nature of the habitat and the poor condition of the existing shell it would perhaps be best to withdraw this species from the Perthshire list. Such a course has already been adopted by the Conchological Society(3).

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XXV.—Plumatella repens.

By CYRIL WALMESLEY.

(Taken as read, 10th February, 1933).

In September, 1931, when cleaning out Muirhall Reservoir, Perth, the writer found a number of colonies of *Plumatella repens* adhering to the East and South walls, about 15 inches from the bottom of the reservoir and 17 feet below the normal surface level of the water.

No colonies were noticed on the west or north walls.

About 50 per cent. of the *polyps* examined were living, and a good many *statoblasts* were found.

A single colony, believed to be *Lophopus crystallinus*, was found, but, unfortunately, was accidentally destroyed before it had been properly examined.

The writer is informed by Mr. Ritchie that these *polyzoa* have not previously been recorded in Perthshire.

It is of interest to note that this year (1933) two other reservoirs of similar size and construction and fed from the same source, were emptied for cleaning in July and September respectively, but although the writer specially searched for *polyzoa*, none were found.

The above mentioned reservoirs consist of rectangular tanks, carrying a depth of 18 or 19 feet of water, which enters by a vertical pipe at the centre of the reservoir and at a height of 4 or 5 feet above the floor. The walls are faced with brown glazed bricks or tiles.

XXVI.—Perthshire Hieracia (Continued from Page 97).

By E. SMART, B.A., B.Sc., F.R.S.E.

(Read March 10th, 1933).

In reviewing the syllabus of the past session and the attendance at the meetings I regret to report that the support given by the members of the Society to the afternoon excursions has again been disappointing. The reason for this is doubtless mainly due to the occurrence on the same day of other excursions in which members are interested, and to the increased opportunity for amusement and recreation in various forms of sport. The autumn excursion to the Wicks of Baigly was full of interest in view of the Scott Centenary celebrations, and the few who attended found much pleasure and profit from the animated discussion which enlivened that outing. But while the afternoon excursions were poorly attended, the mountain excursion at the end of the season continues to be well supported, and a large party turned out in September for the ascent of Ben Lawers. Visibility, unfortunately, was not too good, but most of the party found their way to the top, and returned with botanical and other specimens which they had collected on the way. These specimens included species of *saxifraga*, *Parnassia palustris*, *alchemilla Alpina* which was reported as growing in abundance on the summit of the mountain, and other plants.

Mr. Ritchie, the curator, and I did not join the party which climbed to the top, but confined our attentions to the lower slopes of the mountain, and we explored with some thoroughness the bed and banks of the Lawers Burn. Mr. Ritchie was a delightful companion. I do not know how many or what various species of insect life he caught and imprisoned in the collecting boxes and tubes with which he was well supplied, but I derived much pleasure and instruction from his description of the habits and characteristics of many of his captures. My special object was to discover what different specimens of *Hieracia* were to be found in the area we explored. You will find from Whyte's Flora of Perthshire that Ben Lawers was a favourite hunting ground for the botanists of the earlier years of the Society, and of

Hieracia alone no less than twenty-one different species are recorded as having been collected on the mountain. I find, in the comparatively restricted search which I have already made, that the most fruitful localities are the shaded nooks and declivities on the sides of the streams and rivulets which course down the mountain side, forming here and there miniature waterfalls with quiet pools below and providing a sufficient supply of moisture for the needs of the plants which have found a footing there. The season was, of course, well advanced, but in the lower part of the Lawers Burn we gathered specimens of eight different species of *Hieracia* still in flower. The collection included specimens of *auratum*, *corymbosum*, *strictum*, *chrysanthum*, *caesium*, *murorum*, *vulgatun*, and, on the high ground, away from the burn, *pilosella*. These were all described in the paper which I read last year, and I need not repeat the description. All of these, with the exception of *caesium*, are noted as having been found by Dr. Whyte and his companions. The omission of *caesium* may not mean that it did not occur in those days, but only that the *Herbarium* contains no specimen of this species from Lawers. Though the whole county was minutely and carefully explored in those early years, yet there should be no cessation of continuous work in this connection, for certain species die out by reason of a changed set of conditions unfavourable for their existence, and new species arise for which the new conditions are more favourable. I have already referred to the almost bewildering number of species of the genus, *Hieracium*. The recorded lists show that practically every botanist who has made a special study of the genus has contrived to make an addition to previous records. While this is only what one would expect, yet the differences between some of the species claimed as new, and the already existing species, are often so slight that only the highly skilled specialist is capable of detecting them, and it is not surprising that we find eminent botanists opposed to this multiplicity of species and inclined rather to regard many of them as merely varieties of a species which has been slightly altered in appearance through the special conditions of the environment. But even with this restriction, the number of species is still considerable, and the question of the origin of so many distinct species has been a subject for investigation and research by many botanists.

Cross-fertilisation at once suggests itself as a probable cause, and this explanation, founded on conjecture and not on experiment, seems to have been at one time accepted. The results of Mendel's experiments on the cross-fertilisation of certain species of *Hieracia* showed that the explanation must be found in another direction. After his classic experiments on cross-fertilisation of the pea, Mendel turned his attention to the *Hieracia* in order to find, if possible, confirmation of the principles which he had found to determine the production of new species with the pea. He selected the genus, *Hieracium*, because, as he says in his paper on the subject, "This genus possesses such an extraordinary profusion of distinct forms that no other genus of plants can compare with it," and "Regarding no other genus has so much been written or have so many and such fierce controversies arisen, without as yet coming to a definite conclusion."

In order to understand exactly what Mendel expected to find we must refer to his original experiments on the pea, as described in Bateson's "Mendel's Principles of Heredity." He took two varieties of the pea, one tall from 6 to 7 feet high, the other a dwarf variety averaging about a foot in height, and he crossed these. The hybrids produced were all tall, and because this quality of tallness appeared in the hybrid to the exclusion of dwarfness, he described tallness as a dominant character and dwarfness as a recessive character. Taking now precautions to prevent any crossing, he allowed the hybrid to self-fertilise, and with the seeds thus produced he reared a generation of plants, twenty-five per cent. of which were dwarf and seventy-five per cent. tall. These again were allowed to self-fertilise, and he found that the twenty-five per cent. which were dwarfs produced only dwarfs, while the seventy-five per cent. which were tall produced a mixture of talls and dwarfs—of these the dwarfs continued to produce only dwarfs, a certain proportion of the talls produced only talls, while the remaining portion of the talls reproduced practically the first generation from the hybrid, *i.e.* twenty-five per cent. dwarfs and seventy-five per cent. talls.

Now this result receives a complete and satisfactory solution if we imagine the germ cells of the hybrid to possess some element in their constitution which determines either tallness or dwarfness, but not both. As there appears no reason why the one set of germ cells should be more numerous than the other, the probability is that the number of germ cells possessing the element that makes for tallness will equal the number possessing the element that makes for dwarfness. Union between these cells would then take place thus :—

1. T T T T D D D D
2. TT TD DT DD

the first line representing the cells equal in number (say four for simplicity) possessing the element determining tallness or dwarfness—the second line representing the result of union. As tallness is the dominant character, the first three members of series 2, representing seventy-five per cent. of the whole series, would be tall, and the last member, or twenty-five per cent. of the series, would be dwarf.

The character of the generations produced from the original hybrid may be clearly understood from the following diagram, taken from the book referred to :—

1. TT × DD

2. TD

3. TT TD DT DD

It is evident that the first and fourth members of series 3 will produce pure talls and pure dwarfs, and will continue to do so. The second and third members will reproduce the first generation from the hybrid.

Now the fertilised ovum of the hybrid was the result of union of two sets of cells—one possessing the power to produce tallness, and the other dwarfness. As the generation from the hybrid was either talls or dwarfs there must have occurred at some time a separation of those elements which make for tallness or dwarfness. This separation, or dissociation, has been termed "segregation," and this was the great principle discovered by Mendel. It will be evident that segregation occurring with other pairs of characteristics would produce a great variety of forms. When two cells with the same characteristic combine we would have a pure product. I am not going further into this, nor to discuss how this clashes with the doctrine of continual selection, but we can see that, on the principle which I have explained, the great variety of species of the *Hieracia* might be accounted for.

As I have said, Mendel was attracted to the study of hybridism in the *Hieracia* on account of the great profusion of distinct forms which the genus possesses. But the results of his painstaking experiments seem to have disappointed and puzzled him. He was able to produce very few bybrids, and this very limited success he attributed partly to the smallness and peculiarities of structure of the florets. The individual florets which form the capitulum are very small, with the anthers united in a tube closely surrounding the pistil. Again, the flower is protandrous, the pollen grains becoming mature before the opening of the bud, and while the female parts are still immature. To prevent self-pollination the anthers must be removed before the opening of the bud, and Mendel found that after he had overcome the difficulty of emasculating the flower, very often the pistil withered away and cross fertilisation was impossible.

In the course of these experiments Mendel is said to have injured his eyesight through the constant strain to which it was subjected. He succeeded, however, in raising a few hybrids which were partially sterile, and these produced the hybrid again, but not any of the parental forms. This result, so contrary to what he expected, puzzled him greatly, and he seems ultimately to have come to the conclusion that in the case of the *Hieracia* we meet with some special kind of heredity.

But we now know that a factor enters into the question of which Mendel was unaware. The *Hieracium* is now known to be parthenogenetic, so that with this plant continued existence is secured by both sexual and non-sexual processes. In the sexual method fertilisation may take place either through pollen brought to it from another flower of the same species, or from its own pollen, for this flower is also self-fertilising.

It is interesting to consider how self-fertilisation is secured in face of the fact that the flower is protandrous. There must be some special contrivance by which the pollen is kept in good condition while the pistil is still maturing.

When the flower opens the already ripe pollen is for the most part carried away by visiting insects, but a residue remains behind. This residue is protected from rain and moisture which would destroy its fertilising power, by the bending over of that part of the neighbouring floret which is extended into the strap-shaped form termed a ligule. When the flower closes at night the ligule of the flower is brought into contact with the residual pollen. When the flower re-opens this pollen remains sticking on the ligule, while the style rapidly lengthens. At a certain stage the two arms of the style split widely and curve round in opposite directions. After the female parts have reached maturity the closing of the flower brings the now receptive stigmatic tissue into contact with the still active pollen, and thus self-fertilisation is effected.

The asexual method of reproduction was discovered by Ostenfeld in 1904, thirty-four years after Mendel's experiments.

Ostenfeld found that even when the anthers and stigma had been removed the flower was capable of producing seeds which reproduced the parent plant. This parenthenogenetic method of reproduction is evidently analogous to the method of propagation by buds, bulbs and bulbils.

Nature does not favour hybridism, and when in exceptional circumstances a hybrid has been produced, it will prefer fertilisation by pollen brought from its parents should they be in the neighbourhood, and the final result will be that only the parent forms survive, the hybrid forms becoming sterile and disappearing. In his study of the *Hieracia,* Linton had hundreds of different species growing side by side in his garden, but failed to produce a permanent hybrid. When a hybrid did appear it either soon disappeared, or reverted back to one of the parent forms. Hybridism is now, I believe, definitely excluded as an explanation of the numerous forms of the species, and the generally accepted view to-day is that the great variety of forms is simply the result of adaption to environment and climatic conditions of existing *Hieracia*, or to species which have disappeared.

We have seen that many of the *Hieracia* have their leaves, stems, peduncles, phyllaries, etc., furnished with hairs, or trichomes, of various kinds, and that this is especially characteristic of the species to be found on the higher altitudes. The simple hairs are as a rule of a dusky white colour, and are frequently so dense as to form a kind of felt-like covering which may be described as pilose, tomentose, etc., etc. The glandular hairs differ from the simple hairs in having their extremities swollen by the division of the apical, or terminal cells into the form of a small knob or bulb. These hairs are of a darker colour than the simple hairs—very often indeed quite black. A further striking peculiarity is the presence in many of the species of numerous black-based hairs. It is interesting to consider what function these epidermal structures may play in the economy of the plant.

The epidermal part of the leaves, stem, etc., is thickened to form the cuticle, and the nature of the cuticle is such as to prevent the passage of gases and moisture to the interior parts of the plant. The surface of the cuticle is, however, broken by the pores (the stomata) and these are so numerous that the surface of the leaf viewed under the microscope appears riddled with holes. The stomata are the external openings of an inter-cellular system of canals, and it is through these openings that the plant receives what it requires from the atmosphere, and discharges waste and unused products. Thus the carbonic acid of the air passes in by the stomata and gets into contact with the chlorophyll containing cells, where it is used in the formation of carbohydrate, sugar, starch, etc., and the oxygen liberated in the process, returned to the air. Again, we have in the plant, as in every living thing, a continual process of oxidation going on, and it is by the stomata that the respiration of the plant, *i.e.* the taking in of oxygen and the giving out of carbon dioxide is effected. The stomata also render possible a third important function, viz. : the entrance or exit of aqueous vapour, or transpiration as it is termed. Now it is in connection with the purposes served by the stomata that the epidermal structures play an important part.

One important function discharged by the hairs, or trichomes, is that of preventing too great an exhalation of vapour through the stomata and, when the circumstances require it, of absorbing moisture from the air and passing it in to the inter-cellular spaces and thence to the neighbouring cells. We must not forget, of course, that transpiration is also greatly modified by the action of the guard cells of the stomata, which change their form in such a way as to produce a widening or constricting of the opening, according to the condition of the plant—but the overlying hairs give valuable assistance. And the hairs also protect the plant from receiving too much moisture from the atmosphere—which might easily happen if the stomata were exposed unprotected to the action of direct rainfall. After a shower of rain, drops of water may be observed on the hairs, while the underlying stomata are quite dry.

The protection afforded by the covering of hairs against excessive exhilation of aqueous vapour is beautifully exemplified in *Hieracium pilosella*. The leaves of this species lie in the form of a rosette on the ground, the upper surface being green, while the under surface is white by reason of the close felt-like covering of white stellate hairs. If no rain has fallen for some time, and the ground consequently gets dried up, the leaves will be observed to curl up and present the under surface with its protective covering to the sunlight, thus restricting the heating of the tissues, and reducing the amount of evaporation through the stomata. It will also be evident that this non-conducting protective covering, while protecting the tissues from being overheated, will also help to prevent a loss of heat when the temperature of the air falls so low as to endanger the life of the plant. Apart, however, from the protection against the danger of overheating or overcooling, the covering of hairs is also a protection against too much light. While light is essential for the well-being of the plant, too glaring a sunlight destroys the chlorophyll corpuscles and the toning down of the light by this protective screen helps greatly to secure vigorous and healthy growth.

I have already mentioned that it is particularly in the mountainous regions, where the soil is often scanty, and liable to be quickly dried up in the summer, that we find the species most amply provided with this defensive equipment. In the Alps, where these rigorous conditions especially obtain, we find that many of the plants have both leaves and stem thickly covered with hairs—a notable example, of course, is the *edelweiss*. On the other hand, in Arctic regions, where the soil does not get dried up, the leaves of the plants are smooth, green, and without hairs.

The protection against excessive evaporation supplied by the hairs may also be supplied by the gummy, or resinous, substances to be found on many of the plants. In those species of the *Hieracia* whose peduncles and phyllaries are abundantly provided with glandular and black-based hairs, if the flower be pressed in the hand the presence of this gummy secretion will be at once observed. The contents of the cells of these glands and black-based hairs are of a dark colour, and of a viscid, or gummy, character, and seem peduncles and phyllaries are abundantly provided with glandular and black-based hairs, if the flower be pressed in the hand the presence of this gummy secretion will be at once observed. The contents of the cells of these glands and black-based hairs are of a dark colour, and of a viscid, or gummy, character, and seem to serve both for the prevention of the drying up of the cells and for the absorption of water. In dry weather the gummy secretion becomes hardened and dry and affords a good protection against evaporation; in a moist atmosphere on the other hand the cells swell up, absorbing moisture from the air and, in solution, nutrient material, such as ammonia. This moisture, with its content of nutrient salts, is passed on to the underlying tissues and is there used up for the needs of the plant.

Many of the *Hieracia* have characteristic purplish markings, or blotches, on the leaves and stems—e.g., *H. vulgatum*, *H. corymbosum*, etc. The function of these markings, due to colouring matters to which the names *anthocyanin* and *erythrophyll* have been given, has, I understand, not yet been clearly made out, but they are not found on those *Hieracia* which are abundantly supplied with hairs from which it may legitimately be inferred that these coloured patches function in some respects similar to the hairs. We can, of course, not unreasonably conclude that they may act as a filter in preventing the entrance of certain light rays which might be injurious to the plant by their action on the contents of the cells in preventing the transmutation and transmission of those materials which are essentially to its well-being. It has also been suggested that these colouring matters are an agent capable of transforming the energy of light into the energy of heat, and thus greatly aiding the healthy growth and life of the plant. The only difference between light and heat is in the wave-length—heat, the lower form of radiation, having the greater wave-length. This conjecture regarding the transforming power of these coloured compounds receives support from the the consideration that these coloured blotches are to be found principally on the under surface of the leaves. Light passing from the upper surface of the leaf and effecting metabolic processes on the way, ultimately finds its way to the under surface and comes into contact with the layer of anthocyanin, where, instead of being passed out, and so of no further use, it is transformed to the lower form of radiation and thus made still to serve the needs of the plant. This would, of course, be in accordance with our ideas regarding the economy of Nature. Experience shows us that all forms of energy serve some useful purpose, and that in Nature all waste is avoided.

XXVII.—Petrography of the Intrusive Igneous Rocks of South Angus.

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(Taken as read, February 10th, 1934).

I.—Introduction.

The following notes are intended as a minor contribution to the descriptive igneous petrography of South Angus. If the one-inch to the mile scale map, sheets 48 and 49, of the Geological Survey of Scotland be consulted, it will be observed that within a semi-circular province of about ten miles radius around Dundee, there are a number of areas shown in carmine. These refer to a series of igneous intrusives that intersect flaggy sandstones and lavas of Lower Old Red Sandstone age. The map margins convey the information " diabase " or " felstone." It is those diabases and felstones that form the subject of the present paper.

Professor James Geikie, who originally examined South Angus on behalf of H. M. Geological Survey, adopted the nomenclature of the period in his indentifications of these rocks. Thus in his admirable text-book, " Outlines of Geology," 1886, chapter VI., " Eruptive Rocks, their mode of Occurrence," he refers to the intrusions of Dundee Law and Balgay Hill, Rossie Hill, Blacklaw, etc., as consisting of varieties of basalt, diabase, or melaphyre. Professor Geikie believed that these masses were either occupying the chimneys of old volcanoes, which had contributed by their discharges to the great sequence of andesitic lavas that now build up the Braes of the Carse and the hills of North Fife, or that perhaps never having reached the surface they represented the hypabyssal equivalents of these same rocks.

Sir Archibald Geikie in his classical work on the old volcanic phenomena of the rocks of Britain does not, unfortunately, make any detailed reference to the Angus intrusions. He describes them as " compact andesites," and in specific mention of the rock of Dundee Law incorporates a brief petrographic report by Dr. Hatch in the following terms :—" Striped lath-shaped felspars, abundantly imbedded in a finely granular ground mass speckled with granules of magnetite, but showing no unaltered ferro-magnesian constituent." Reading his account of the Ochil and Sidlaw eruptive history, one can have no doubt that Sir Archibald Geikie also regarded these rocks as being in some way directly connected with the great igneous cycle of Lower Old Red Sandstone times.

In a recent dissertation by Dr. John Harris, Dundee, entitled "The Intrusive Igneous Rocks of the Dundee District," published in the Transactions of the Geological Society of Edinburgh, Vol. 12, 1928, petrographic descriptions are given, along with chemical analyses, of some of the rocks in the near neighbourhood of the city. Dr. Harris's paper has enabled me to curtail certain portions of my manuscript, and it must necessarily be consulted by all readers interested in the geology of the area.

II.—Field Characters of the Intrusions.

Resulting probably in large measure from the thick mantle of drift that sheets over the district, rock exposures are not always such as a geologist might wish, and this is why it has been found possible to delineate upon the Survey sheets in approximate fashion only the extent and relations of many of the masses with which this paper is concerned. A first result of this unfortunate condition of things is that some of the rocks now mapped as being intrusive in origin may in reality be lavas. Such an opinion finds support from the fact that some of the rocks show an excellently preserved flow structure. But that the majority of the rocks are intrusive can scarcely be doubted, for the manner in which their form, even when this is only approximately known, transgresses the strata with which they are associated, and the fact that where their margins have been exposed they are always found to contact alter the rocks against which they abut point only to such a conclusion.

It may now simplify matters if it be repeated that two main field types have been found to occur among the intrusive rocks of South Angus, viz., dark coloured basic-looking rocks that it is proposed generally to call Diabases, and light coloured acid-looking rocks that may appropriately be designated Felsites.

The diabases, as indicated, are usually dark coloured rocks, and are occasionally so coarsely grained as to resemble in texture some of the typical quartz dolerites of the Carboniferous areas of Fife, and the Lothians. More frequently, however, a microcrystalline somewhat basaltic rock is found, which is tough under the hammer and provides a useful and extensively wrought material for macadamising the public roads. As examples of these types may be cited respectively the rocks of Balgay Hill and Dundee Law. A common feature among the diabases, or at all events among the majority of them, is the occurence of red acid segregation veins that carry abundant pink felspar. Sometimes these veins are quite narrow, forming mere strings, usually of fine texture, running sinuously through the dark rock, or, again, they may be several feet or yards across and so coarsely grained as to look like some pink granite. Patches also of similar material are to be seen which are not in visible connection with any vein whatever. Especially to advantage can these features be studied in the great intrusive mass that extends north from Rossie Priory to Blacklaw Hill. The most interesting exposure of this sheet is in a quarry at Hilltown of Knapp where the rock has been worked for road metal. The number of apparently different petrographic types that can be collected here in a short time is quite surprising. Numerous instances of similar differentiation can be detected among the diabase intrusions of the district, and as convenient of access may be mentioned the masses of Dundee Law and the intrusion exposed at Craigie and Baxter Park (both of which are within the burgh boundary of the city of Dundee) where the phenomenon although manifested on a less extensive scale is nevertheless displayed with great clearness. Many of the diabases show columnar jointing and a tendency to weather spheroidally is frequently observed.

In reference to the field characters of the felsites a great deal need not be written. Generally they are red, pink, or buff coloured compact rocks, sometimes markedly porphyritic in respect of felspar. To especial advantage can examples of this type be studied where the mass of Balgay Hill is mapped as coming down to the shore, west of the Tay Bridge. Here instructive sections have been laid bare in the Dundee-Perth rail cutting and on the adjacent beach, disclosing a series of bright pink intrusive rocks intersecting the Lower Old Red flags and sandstones, indurating them and enclosing many xenolithic fragments. Some of the felsitic rocks here seen, rather exceptionally, carry numerous phenocrysts of lustrous dark biotite.

As affording an introduction to the microscopic study of the rocks to which the above convenient field terms "diabase" and "felsite" have been applied, it may be explained that the diabases have been ascertained to include quartz hypersthene dolerites, basalts, augite porphyrites, and andesites, and that the felsites have been found to afford examples of albite trachytes, andesine-albite porphyrites, and plagiophyres. The characters of all these types will be briefly indicated below. It should be noted that very many of the Angus intrusions are in a highly altered condition and the localities cited are merely those that I have found to yield the most helpful and informative material.

III.—Petrography of the Diabases.

Quartz hypersthene dolerites. The great intrusion indicated on the one-inch map as stretching north from Rossie Hill to the hamlet of Lundie covers about eight square miles of country. As displayed in the quarry at Hilltown of Knapp, the rock is massive, not well jointed, and weathers spheroidally in the higher portions of the worked face. As previously observed, a wide variety of lithologic types can be collected at this exposure, ranging from a medium-textured thoroughly basic-looking whinstone to coarse-grained red-coloured rocks possessing a syenitic or granitic appearance. The latter are found in segregations and veins that intersect in all directions the main body of the rock. Some of the vein rocks are compact and saccharoidal, but others are coarsely crystalline and carry numerous aciculae of alkaline felspar.

Microscopically examined, the dark coloured main mass of the Knapp intrusive is a plagioclase-pyroxene rock, which in the absence of chemical analysis and judging from the optical basicity of the felspar can safely be described as a quartz dolerite. The micro-structure is non-ophitic. The soda-lime felspar has indices of refraction ranging above and below 1.562, indicating intermediate labradorite. But in addition to felspar of this composition, there is also a proportion of acid plagioclase ranging down through oligoclase to albite. The pyroxene is of two kinds, monoclinic and orthorhombic, the former pale brown in colour and the latter almost colourless. The monoclinic form tends to occur in groups of variously oriented prismatic granules and crystals. Sometimes, however, a larger plate may be observed enclosing the more basic felspar in sub-ophitic fashion. But in no sense can it be said that an ophitic habit is characteristic of the Knapp dolerite. The rhombic pyroxene is rather an inconspicuous ingredient, occurring only in relatively small amount. It builds rounded prisms that are often intergrown with the monoclinic form. A little brown or barely tinted hornblende has been developed along the margins of the monoclinic pyroxene. Ilmenite occurs in plates that sometimes enclose both the felspar and the ferromagnesians. Interstitial patches of crystalline silica, against which the other constituents are sharply bounded, afford evidence of the saturated character of the rock and point to the fact that of the numerous serpentinous, chloritic, and micaceous, pseudomorphs present probably none belongs to olivine. A little red biotite is visible in the rock sections contiguous to the iron ore, and apatite is of sporadic occurrence, being abundant in some sections of the rock and relatively rare in others.

The above notes refer only to the average dark body rock of the Hilltown of Knapp intrusion. In many examples of the acid rock the pink alkaline felspar looks like orthoclase, but can usually be distinguished from that mineral by its possessing a fine polysynthetic twinning and showing oblique extinctions. In some sections the substance occurs in slender needles elongated parallel to the first crystal axis. Sometimes those needles are simply spinules of untwinned albite, but more frequently they are once twinned on 010 and have a narrow border showing a fine striation. The indices of refraction range round the value 1.530, the axial angle is wide, and the sign positive. But in some cases a negative character has been noted in conjunction with a narrow angle and fine albite striae, so it seems likely that anorthoclase is present. The interstices between the needles are filled with microcrystalline silica, crowded with granules of ilmenite, and mixed with chlorite, calcite and turbid felspathic substance. Usually the acid rocks carry little prisms and ragged flakes of pale coloured hornblende, large crystals of ilmenite both of early and late separation, abundant apatite, and sometimes plates of diopsidic augite, in process of amphibolisation and replacement by quartz and calcite.

Another type of the acid rock at Knapp is a pink saccharoidal variety, this being a material of about I mm grain and consisting of little squares and oblongs of albite with abundant interstitial quartz, calcite, chlorite, pale green-brown pyroxene, greenish amphibole, iron ores, and scattered apatite. Associated with the amphibole, dark blue riebeckite occurs not infrequently, affording testimony to the soda-rich character of these segregation rocks. It may be added, that yet another modification consists in large part of albitised soda-lime felspar microlites, the microscopic appearance then resembling in striking manner the type usually designated spilitic diabase.

Hypersthene dolerite has been described from Balgay Hill by Dr. Harris. This rock like that of the Hilltown of Knapp is of non-ophitic habit, and consists of plagioclase felspar, augite, hypersthene, apatite and iron ores, along with an abundant felspathic, sometimes micropegmatitic, residuum filling the interspaces. The felspars are mainly labradorite zoned down to oligoclase and albite, but anorthoclase is probably also present in small proportion. The orthorhombic pyroxene occurs here much more abundantly. It is optically negative, has a mean refractive index of 1.70, and contains an $FeSiO_3$ content of 20 per cent. The monoclinic pyroxene has a normal axial angle of 54 degrees. In some notes made by me many years ago there is an entry relating to the occurence of pyroxene in the Balgay dolerite with narrow angle. But I have not lately confirmed this observation. The red brown interstitial residumm of the rock is richly charged with incipient growths of iron ore and apatite, and not rarely shows a sub-variolitic grouping of feathery felspar microlites. In some microscopic slides of the Balgay rock a pale coloured biotite appears associated with the monoclinic pyroxene, and when this proves to be the case the hypersthene is not in evidence.

In addition to the above noted field occurrence of hypersthene dolerite others have been found in the channel of the Gelly Burn, immediately north of Mains Castle (Dundee); in the railway cutting at Fairmuir; on the shore about two miles west of the Tay Bridge (Dr. Harris); at Glack Hill, 600 yards north-east of Duntrune House; also at North Balluderon, one half mile north-west of the farm, as well as elsewhere in the district. But nearly all of them duplicate features that can be observed at the Hilltown of Knapp, or are already known from other descriptions of quartz hypersthene dolerites. Albitisation is a common feature, and especially to advantage can this type of alteration be observed in an old quarry 300 yards west of Mains Castle, or at the interesting exposures at Glack Hill and North Balluderon. A decomposing rock occurs in the ravine north-west of Whitehillfaulds carrying pink albite felspar, very faintly purple diopsidic augite, highly dispersing soda amphibole, apatite in stout prisms, and opaque ore. The replacement of augite by quartz is here displayed in great perfection, and the occurence is certainly deserving of further study on account of the interesting ferromagnesians present.

Basalts—Basaltic rocks of ophitic habit occur at Wester Rochelhill, one and a half miles south of Glamis ; at Auchterhouse Hill and Scotston Hill ; also at Newton, south-west of the main road to Newtyle (about eight and a half miles from Dundee).

The small mass exposed on the road at Wester Rochelhill is a plagioclase-pyroxene rock of doleritic texture, showing a fluxional arrangement of labradorite laths, along with ophitic clumps of purplish titaniferous monoclinic pyroxene, and carrying ilmenite and apatite as accessories. Occasional phenocrysts of labradorite zoned with inclusions are present, and there is a little residual glass along with interstitial soda-rich felspar.

The large intrusion indicated on the map as extending north from the summit of Auchterhouse Hill is, unfortunately, but poorly exposed. Where visible, however, the rock shows itself as a dark grey or black substance, much jointed and attacked by the weather. Microscopically, this rock is a finely ophitic basalt with a ground structure somewhat recalling the Jedburgh and Kilsyth types, so well known among the Carboniferous lavas of Scotland. Essentially the rock consists of a felt of labradorite laths held together by ophitic coagula of monoclinic pyroxene and sub-ophitic hypersthene. The usual accessories are apatite and ilmenite. The felspars are beautifully bordered by sodaclase. Only the more basic portions of the felspar penetrate the ferromagnesians, and there is a little interstitial quartz. Many of the ferromagnesians are chloritised. It should be noted that in those sections which show the best ophitic structure the hypersthene is scarcely so evident.

Just beyond the wall forming the western boundary of Auchterhouse plantation, rises the iceworn summit of Scotston Hill bare of mantle save a scant coat of heather. The mass is well jointed, compact, and weathers spheroidally. A fresh fracture reveals a finely crystalline blue material. Under the microscope the rock is not fresh. It carries a few phenocrysts of plagioclase, is ophitic in habit like the rock of Auchterhouse, and shows in some sections an abundance of dark brown glass. Some rare serpentinous pseudomorphs suggest the former presence of olivine in the Scotston Hill Rock.

A rock differing in its characters from any of the masses above referred to builds the tract of high ground known as Pitnappie Hill, and which extends from near the railway station at Auchterhouse south-west towards Lundie. As exposed in the quarry south from the farm steading of Newton, the rock is fine grained, granular, and with a tendency to break into plates and slabs, so that good material is not easy to collect. The summit of the hill is covered with rough pasture and, though evidences are not wanting that the igneous rock must be quite near the surface, it is not until the elevated tract behind Clushmill is reached that there is another satisfactory exposure. The rock at this locality appears slightly coarser than at Newton, and differs from it in the possession of a microporphyritic character. Likewise it is here somewhat difficult to obtain suitable material for petrographic examination.

The Newton rock consists of a plexus of (60 per cent. anorthite) labradorite laths, along with 2 mm. ophitic plates of pale brown augite, and a variable amount of iron-rich fresh brown glass. Enclosed in this aggregate are numerous idiomorphic I mm. crystals of olivine, many of which are quite unaltered or but little serpentinised. Slender needles of apatite and sub-ophitic opaque ores are constant accessories. Occasionally the glass content increases considerably in amount, and the rock then virtually passes over into an andesite. At Clushmill the ophitic habit is lost and numerous phenocrysts of soda-lime felspar appear ; olivine, however, persists. These rocks, especially some of the specimens obtainable from the old quarry at Newton, strikingly recall certain of the well known olivine tholeiites of the Saar-Nahe district.

At Kirkton of Strathmartine and Shielhill, both north of Dundee, ophitic, subophitic, and non-ophitic, andesitic basalts occur. At the latter locality probably a slight movement of the crystallising rock has partially destroyed the ophitic structure, breaking up the pyroxene plates into granules and conferring a somewhat schlierened character upon the mass.

Augite Porphyrites.—Typical members of this group of rocks occur at Dundee Law and Craigie, within the burgh boundary of Dundee. These masses have already been described by Dr. Harris, to whose paper reference should be made. The first noted, in the field a basaltic aphanite showing dark microphenocrysts of augite, was formerly well exposed in quarries upon the north side of the Law Hill, passing into a red coloured acid saccharoidal modification, and associated also with a white aplitic material that resembled in hand specimen some fine grained quartzose sandstone. The Craigie intrusive builds much of the high ground at Baxter Park, and has been extensively worked at the Gallows Hill or Craigie quarries for road metal. There it is a close textured compact rock with columnar jointing.

Fine red segregation veins and patches are abundant in the mass, and mineral druses are not uncommon, some of which are lined with pink scalenohedra of calcite. At the top of the worked face the rock exhibits a tendency to spheroidal weathering.

An average example of the rock of Dundee Law shows a ground web of andesine-labradorite laths, which encloses numerous anhedra and sub-ophitic granules of monoclinic pyroxene, idiomorphic prisms of hypersthene, ilmenite or titaniferous magnetite, apatite, quartz, and an abundant interstitial residuum of warm coloured potash-albite or anorthoclase. The grain of the rock is generally under .5 mm. The monoclinic pyroxene occurs in micro-crystals of two generations. Rarely do those of early separation occur in idiomorphic form; generally are their margins indented by the ground felspar laths. They tend to occur in glomerporphyritic groupings. A sahlite striation may frequently be observed, both in the phenocrysts and individuals of smaller size. The augite and hypersthene are often intergrown and each shows the micaceous type of alteration noted by Sir J. S. Flett in the quartz dolerites of the Edinburgh District.

About five years ago, an interesting series of rocks upon the flank of Dundee Law was cut through at Dudhope Park, in the course of constructing the new highway between Constitution Road and Lochee Road. These were found to consist of fine textured pyroxenic aphanites, strikingly associated with red, sometimes markedly, porphyritic rocks. The dark rocks differed microscopically in no essential from the Law summit specimens. Some were much richer in hypersthene and, indeed, carried that mineral as phenocrysts. A few were biotite rich, whilst others were leucocrates. The more acid rocks collected from the cutting ranged from grey to red coloured rocks, the latter including oligoclase porphyrites with a microcrystalline ground consisting in large part of turbid red albite and quartz.

Many other excellent examples of augite porphyrite occur in South Angus. The rock at Baxter Park is scarcely in as fresh a condition as that of the Law. This rock, in addition to carrying porphyritic vein rocks corresponding to some of those at Dudhope Park, shows narrow strings of red acid material lined with anorthoclase and fine micropegmatite. Deserving of special mention, too, are the exposures at Dundee Bleachfield (Longhaugh), and in the fields half a mile south of the Barns of Wedderburn. At these localities I have collected some of the finest pyroxenic porphyrites anywhere to be found in the district.

It requires indeed sustained application to investigate microscopically the igneous intrusions of South Angus. The rocks are very old and they have been much attacked by the weather. Frequently can it be observed that of their primary mineral construction not much remains. Hence is it possible to make only slow progress towards an understanding of the original character of the masses.

But the study of their internal transformations ought not to be neglected. Thus may I here appropriately refer to the phenomenon of albitisation, which is one widely exhibited by the plagioclasic rocks of the district. To the corresponding type of replacement as occurring among certain of the more acid rocks it will be necessary to refer later.

Six miles to the west of Dundee, near Castle Huntly, two areas of intrusive igneous rock are shown on the map. The larger mass, of a rudely triangular outcrop, has one side abutting against a branch of the great Firth of Tay fault, which with its complement on the north side of the Carse of Gowrie lets down the Upper Old Red Sandstone into the arch of the older rocks. The other, a small circular boss or stock, affords the foundation upon which the house of Castle Huntly stands. These masses are well exposed in a number of field bluffs south from the village of Longforgan, in a large quarry at the northern entrance to the grounds of Castle Huntly, and especially around the base of an old dovecot close to the farm steading bearing the same name; also in proximity to the Castle itself. In hand specimen the rocks are variable in colour, some are blue-black and basaltic looking, others are pinkish and suggest a teschenitic affinity. The use of a pocket lens does not render much assistance towards making more clear the nature of these masses. All that can be seen is that there is a large amount of resinous looking substance and occasional glistening faces that suggest felspar cleavage planes.

Microscopically the Castle Huntly rocks are seen to have been fine textured basaltic or doleritic porphyrites consisting in the main of plagioclase and monoclinic pyroxene, and showing the accessory constituents biotite, apatite, and ilmenite. But profound albitisation has affected the masses. A large amount of lime has been set free and there is much calcite visible in the sections. Chlorite and migrated chloritic matter, in the form of veins, clusters, and felspar replacements, also occur, and often there are vesicles present lined with water-clear albite felspar and filled with chlorite. Where secondary albite has taken the place of the original felspar, it is usually the centres of the crystals that have been replaced first, the result being that we find a core of turbid or translucent albite framed in the marginal primary clear felspar, which consists of albite or albite-oligoclase having refractive indices lower than the balsaam of the slides. Occasionally it can be seen that, although replaced by secondary albitic matter, the original albite and Carlsbad twinning-planes have been preserved. To treat at further length of these Castle Huntly rocks would be merely to re-traverse what has already been sufficiently explained by Messrs. Bailey and Grabham, and by Sir J. Flett and other writers. They afford, indeed, a beautiful demonstration of the albitic type of metasomatic transformation, and especially in this respect ought I to direct attention to the rock upon which the old dovecot stands, near Castle Huntly home farm.

Andesites—The substance of the intrusion stretching for over two miles to the south west of Monikie reservoir can be satisfactorily examined in a large quarry which has lately been opened upon the south side of the mass, as well as along the flanks and on the summit of Cunmont Law. Specimens from the summit of the hill are dark and lustrous looking, reminding one somewhat of the pitchstone porphyrites of the Cheviot District and Ochil Hills, with which there is the further point in common of carrying veins of dark red chalcedony. Microscopically the rock of Cunmont Law is a felspar-phyric andesite of somewhat coarse texture carrying abundant glass. Where the vitreous matter diminishes in amount the rock passes over to a tholeiitic type. Along with the second generation of felspars in the ground occur monoclinic and orthorhombic pyroxenes, the latter, however, only rarely. Both ferromagnesians occur, too, as sporadic phenocrysts. A few serpentinous pseudomorphs indicate the former presence of olivine.

The porphyritic felspars, judging from their optical extinctions, include an anorthite content of about 60 per cent. And their indices of refraction compared against the data furnished in the mineralogical text books confirm such an inference. Many of the crystals show evidence of resorption ; they tend to occur in glomeroporphyritic groupings, and they are often completely fenestrated or latticed with inclusions of glass, and granules and optically continuous coralloid growths of augite. In size the phenocrysts range up to 4.5 mm. in length and then have a breadth equal to about half that amount. The felspars of the ground do not appear noticeably more acid and the microlites measure in length .5 mm. or thereby.

The glass of the Cunmont rock is sometimes quite fresh when the sections afford unusual interest. The refractive index is low, being less than that of hard balsaam. Segregations, into cavities and around dissolving xenolithic granules of quartz, with peripheral growths of augite are not uncommon, and often lanes and ramifying channels occupied wholly by glass are discernible. The vitreous matter is of a russet-brown colour and is full of tufted feathery, or brush-like, growths of pre-felspar, and rods and bars of incipient pyroxene dotted with granules of magnetite. Throughout are generating nuclei of devitrification, marking the dark background with sap green patches and lighting up the field under crossed nicols.

From Balbeuchley, Lundie (half a mile E.N.E. of Ardgarth), Todhills (half a mile E. of), and elsewhere other andesitic types have been collected, many of them greatly altered and devitrified. Some of the rocks on the contrary are comparatively unchanged and deserving of further study. Thus the andesite of Todhills is in a condition corresponding to that of Cunmont. An interesting occurrence is that forming the intrusion at St. Bride's Ring. The substance of this mass is exposed in a large quarry on the east side of the road running past Kingennie House. A curious pillowy appearance on the higher parts of the worked face recalls the structure of the ellipsoidal basalts. South-west of the quarry, on the road at Kingennie station, a pinkish amygdaloidal rock is seen which is indicated on the one inch map as forming part of the same intrusion, but the respective characters of the two rocks do not suggest that they belong to the same body. The complexion of the St. Bride's Ring rock is perhaps basaltic rather than andesitic. The glassy ground is crowded with idiomorphic grains of augite, and squares, oblongs and needles, of magnetite, and a pleochroic titaniferous mineral. The rock is markedly porphyritic in respect of felspar, and phenocrysts of augite and hypersthene, resorbed and replaced by opaque ore, are also found.

IV.—Petrography of the Felsites.

In the neighbourhood of Dronley, about five and a half miles north-west of Dundee, an igneous intrusive mass is indicated on the one-inch map, occupying about a square mile of country. The material of the intrusion can conveniently be examined in the railway cutting to the north of Dronley, also and more advantageously a short distance to the west, in the large quarry by the side of the main Dundee-Alyth road. The rock tends to be amygdaloidal in places, is dark pink or buff coloured in the hand specimen, and shows but, not invariably, a platy fracture, then exhibiting a somewhat lustrous appearance on the structural surfaces. Microscopically the rock is a quartz albite trachyte or keratophyre. Save for occasional minute shreds of red brown biotite, the rock shows no unaltered ferromagnesian, but on the other hand abundant calcite and chlorite. The ground is a fine trachytic felt of closely packed felspar laths, which consist of albite. Patches of quartz are usually in evidence, and scattered little rods, oblongs, and squares, of iron ore, along with slender needles of apatite, occur as accessories. Occasionally a porphyritic character is developed and microphenocrysts of albite appear, but these are of uneven distribution.

Although there are many rocks in South Angus agreeing in mineral composition with that described above, not all of them are possessed of the same trachytic structure. Types, however, which may fairly be ranged with the Dronley rock occur at Keithall, about 1½ miles south-west of Dronley station, and in the Den of Fithie, near Windymill, about 5½ miles due east of Dronley, where a pink compact abundantly microporphyritic rock invades the hard fine-grained flaggy sandstones.

To the other felsitic rocks of the district I shall advert only in the briefest manner. Reference has previously been made to the cutting driven through between Constitution Road and Lochee Road, within the burgh boundary of Dundee. Here, in addition to pyroxenic porphyrites, were exposed a number of interesting more acid rocks, some of them pale pink in colour, others dark purple and showing a microcrystalline or aphanitic ground, and many of them carrying megaphenocrysts of plagioclase felspar. Although the cutting traversed rocks of very different field appearance, I am not prepared to say that any sharp transitions or chilled boundaries were evident. Rather the component members appeared to pass into one another, suggesting either some *in situ* differentiation explanation, or more probably, one involving composite or short interval intrusion. It is only to the pink and red coloured rocks that I now refer. Some of these proved to be remarkably fresh andesine porphyrites, carrying 4 mm. equidimensional phenocrysts in a microcrystalline ground of similar square ended felspar crystals, along with interstitial quartz and potash-albite or anorthoclase. Dispersed chlorite, apatite, ilmenite and leucoxene, are regularly present, and not infrequently cross-cuts of unaltered biotite, or biotite replaced by granules of iron ore. Sometimes the quartz of the ground occurs in poikilitic areas, in the midst of which lie numerous little idiomorphs of soda-rich felspar or anorthoclase. It is an interesting feature of these rocks that very often they are in process of being albitised. Many sections show that whatever andesinic substance the rocks contain is partly converted to albite. Complete substitution by albite leads easily to the next type found here, namely, albite porphyrites, corresponding precisely in texture to the rocks whence they were derived. But the felspathic substance invariably reveals its secondary origin, being turbid and usually crowded with chloritic granules. Albite porphyrites are not of rare occurrence in South Angus. A splendid display of such rocks can be seen in Duntrune or Ballumbie Den, east from Dundee, where, however, the ground of the rocks tends to consist of laths of albite and to assume somewhat of the texture of the coarser grained andesites.

Where the grain size of the andesine-albite porphyrites diminishes, and biotite becomes a more obvious ingredient, we pass to the types displayed at Seabraes, west of Dundee. The rocks here exposed show phenocrysts of albite, replacing andesine-oligoclase, and biotite, in a quartzo-felspathic, microlitic, and sometimes micropoikilitic, ground, that encloses large crystals of apatite, and scattered granules and bars of ilmenite. The micropoikilitic type of ground in these Old Red Sandstone acid intrusives is widely distributed in Scotland, being finely developed in some of the felsites of South Ayrshire, in the lonely hill country adjoining the head waters of the Girvan and Stinchar rivers; also at Cairngryfe, in Lanarkshire, at Lucklaw Hill, in East Fife, and elsewhere.

Among the plagiophyres probably the best example is that afforded by the material of the intrusion laid bare in the large quarry near Duntrune House. As here exposed, this rock is massive, not well jointed, and shows a differentiation into blue-black and red fractions. An amygdaloidal structure is apparent in places and there are numerous cavities lined with pyramidal quartz and agate. Microscopically the intrusive is fine in grain. Sections of the dark material exhibit porphyritic crystals of basic andesine or acid labradorite, enclosed in a web of small square-ended laths of similar character, and with interstitial red brown turbid alkaline felspar and quartz. Titaniferous magnetite and apatite are the accessory constituents. Some parts of the rock appear to consist entirely of felspar, though careful examination rarely fails to reveal the presence of chlorite. The red coloured variety of the rock of Duntrune quarry proves to be an albitised representative of the other, duplicating all its textural modifications.

Rocks petrographically resembling the Duntrune mass, although not possessing the same porphyritic character, have been described by Dr. G. W. Tyrrell from the Carrick district of South Ayrshire. In both regions, it is necessary to point out, there is clear evidence of extensive albitisation. Thus the plagiophyres near Maybole (Glenside, Craigfin, Low Burncrook, etc.) appear to-day as soda rich rocks. Dr. Harris determined certain of his types to be of plagiophyric affinity, but, perhaps following Dr. Tyrrell, he withholds comment upon the fact that they are in large part merely metasomatic products of the kind indicated.

Among many excellent examples of albitised plagiophyre in the Dundee district is that skirting the western acclivity of Craigowl Hill, and striking north to Nether Handwick. In some sections this rock presents somewhat of a resemblance to the type usually described as spilitic diabase. In the field the mass exhibits a platy jointing, and has built up a great scree from which good material can readily be collected for petrographic examination.

V.—Conclusion.

In concluding these notes, I should like to thank an old friend, Mr. W. T. Ramsay, of University College, Dundee, who accompanied me upon many traverses over the hills and moors of South Angus. Our excursions, as may be discerned, have resulted *inter alia* in the discovery, within the area, of an interesting series of initially albitic and albitised igneous rocks of Devonian age. I make no claim to have investigated the province with sufficient thoroughness, and there remains a considerable field for further research. A future enquiry might appropriately include the study of certain related soda-rich andesites, that in recent years I have found to have an extended distribution in the hills of Perthshire and North Fife.

XXVIII.—Note on a Pteropod Trochophore found in the Tay Estuary.

By ANN R. SANDERSON, B.Sc., Ph.D.,
University College, Dundee.

(Read 9th February, 1934.)

During the spring months of 1928 I had occasion to make several tow-nettings in the estuary of the Tay above Broughty Ferry. In five successive hauls taken between 21st February and 5th April there appeared large numbers of a bright orange coloured trochophore. The largest catch was taken on 2nd March and included larvae of all sizes. Numbers gradually fell off, and by 11th April the trochophores had entirely disappeared from the catches. The largest specimens taken on 5th April measured about 1.2 mm in length and showed a well developed " proboscis " with hook sacs, otocysts and large lateral " fins." The larvae at this stage remained near the bottom of the tank and maintained a rhythmic flapping of the " fins." This preference for deeper water at this stage may account for the absence of these larvae from the later hauls, but their sudden invasion and rapid disappearance leads one to suppose that the species is not endemic in the Tay, but that it had been carried into the estuary by currents from the North Sea.

I have to acknowledge indebtedness to Miss Massy, Cork, who kindly identified the larvae as trochophores of *Pneumodemopsis paucidens* or allied species.

XXIX.—Note on Mosquito larva from Tay Basin.

(Read 9th February, 1934).

By W. KEIR, B.Sc., University College, Dundee.

During August, 1932, mosquito larvae were collected from the reed-swamp margin of a stagnant pond on the Dighty Burn, a few miles North of Dundee. Many of these were larvae of Anopheline mosquitoes and when reared to the adult stage and examined they proved to be *Anopheles bifurcatus.*

XXX.—*A Survey of the Breeding Places of the Mosquitos of Downfield District, Dundee.*

By W. KEIR, B.Sc., University College, Dundee.

I.—The Scope of the Investigation.

From August 1st until August 30th, 1932, search was made in Downfield district for the breeding places of mosquitoes; larvae and pupae from these places were reared and the species determined from the adults.

II.—Methods.

Collection of larvae and pupae was made, using a shallow vessel with a white bottom, so that the animals could be easily seen. The larvae were then separated into two groups, Culicine and Anopheline, using the siphons and breathing position as criteria: they were then kept in pond water in separate jars, which were closed by mosquito netting. The times of pupation and emergence were recorded. The adults were examined to determine the species, then mounted.

III.—Description of Area, with Results.

The region considered has an area of about two square miles and consists of a section of the Dighty valley, including a cluster of ponds on the high ground to the north and several tributary waters running to the main stream from the ridge to the south. The land is heavily cultivated and wooded in parts. Six stations stretching from north to south across the valley were chosen; these were—Castle Ponds, Black's Pond, Dighty Burn, Gory Burn, a Field Ditch, and Back Burn.

(a) Castle Ponds consist of three ponds once used for curling. The large pond has plenty of water in it, fed by a field burn and a spring. There is a backwater at one end of it, where scum accumulates amongst species of *Juncus* and *Potamogeton*. Trout are present and three-spined sticklebacks are plentiful. Several empty nymph cases of a large fly were seen, but no mosquito larvae were obtained.

The other ponds are muddy and rush-grown; sedges are present. There is not much water and it is stagnant. *Gammarus* was found and several beetles; three-spined sticklebacks are very plentiful. A ditch nearby with running water had only *Gammarus*. No mosquitoes were found in either pond or ditch, but midge larvae were present. (N.B.—In this connection it has been noted by Professor Peacock, working in Southern Flanders, that mosquito larvae accompanying rushes and sedges were found only once.)

(b) Black's Pond (1708) is a marshy spot beside Dighty Burn, at one time a mill pond, now entirely cut off from burn water and stagnant. It is roughly triangular in shape, each side being over 50 yards long. Trees shelter it on all sides ; these are chiefly wych elms on the north and ashes on the south, with some spruces at the western end. Within the limits of the old mill dam, *Arundo phragmites* flourishes, being 6-9 feet high in most places. There is abundance of aniseed, *Pimpinella anisum*, round the edges giving a strong scent to the air. The pool itself has two regions—a small central area of open water with no plants, and a marginal region with only a few inches of water amongst the reed stems, with duckweed, *Lemna* sp., growing abundantly.

The pond fauna consisted of *Daphnia*, *Cyclops*, *Cypris*, several beetles and a leech.

This was the chief breeding place of mosquitoes found. Water samples from the marginal area had about 2 larvae at each dip, while more open water had about 1 at each dip ($\frac{1}{2}$ pint).

Due to the hot weather during this month, the pool lost much water, about 2 or 3 yards round the edge becoming dry, while the central pool became a mere shallow pan over soft, black mud. The fauna was extremely concentrated, several hundred crustacea being obtained at each dip from the central pool. A beetle was found in the marginal portion. There were no larvae in the open water, but about 20-30 were got at each dip from muddy water amongst the reeds. Anopheline larvae, which had been in decided minority before, seemed to have increased to about 50 per cent. of the total numbers.

From this pond were taken and reared :—

Anopheles bifurcatus ... ... 2 females and 1 male.
Theobaldia annulata ... ... 2 females and 3 males.
Ceratopogon pulicaris ... ... 1 female and 1 male.

(c) Dighty Burn, Baldovan (1107). At Baldovan a slow-running sawmill lade breaks off the main stream and flows at a higher level for over $\frac{1}{4}$ mile, leaving a marshy slope between itself and the burn. There are many plants in the lade, *Potamogeton*, etc., which harboured beetles, but no larvae were found.

The intermediate marshy slope supplied pasture for cattle and in the imprints of the hooves of the latter, amongst a slimy scum, small Culicine larvae were found in fairly large numbers. One specimen of *Theobaldia annulata* was reared from these.

(d) Gory Burn (0508) is a small stream running between fields, having its source in Clato Reservoir and falling into the Dighty at Baldovan. The water is very clear, but a large amount of surface drainage must take place. In the part examined (along the foot of Baldragon Strip) the banks are high and lined by dog rose and nettles. There were great numbers of water skaters, a few *Gammarus*, and many May fly larvae. No mosquito larvae were found.

(e) A Field Ditch (0703) containing running water only at certain periods, drying up to a chain of small pools in summer, was examined : the water is from surface drainage only. A beetle was found here, but no mosquito larvae.

(f) Back Burn (0702) is a small burn flowing out of Camperdown Ponds through Camperdown Woods and cultivated fields ; it is fairly clean with no weeds actually in the water ; few parts ever become stagnant. *Gammarus* and a beetle were present, but there was no sign of mosquitoes. Midge larvae and May fly larvae were found.

IV. Summary and Conclusion.

1. In the section of the valley of a stream, breeding places of mosquitoes were found only in the low-lying marshy ground adjoining the stream.

2. In these places, two of which were examined, both giving positive results, mosquitoes bred freely.

3. Anopheline and Culicine mosquitoes were obtained from water with reeds and duckweed as accompanying flora ; Culicine mosquitoes alone were found in slimy marsh with grass ; no mosquitoes were found in water where sedges grew ; while midges were found in almost any water.

4. The interval between pupation and emergence was 7 days for all mosquitoes reared.

5. Species reared from larvae found in this district were :—

Anopheles bifurcatus	both sexes.
Theobaldia annulata	,,
Ceratopogon pulicaris	,,

XXXI.—*A Short Cist found at Bridge Farm, near Meikleour, Perthshire.*

By JOHN RITCHIE, F.R.A.I.,
with a description of the Skeletal Remains
By MARGARET G. L. RITCHIE, L.D.S.

(Read 9th February, 1934).

On 9th August 1933, Mr. Stirling, tenant of Bridge Farm, near Meikleour, informed me that while engaged in taking gravel from a hillock, he had exposed a large flat stone which was about a foot from the surface, and that on lifting the corner of it he observed a few bones.

On 10th August I visited the site, and ascertained that during the interval someone had dislodged the stone and removed from underneath a human skull, parts of a pelvis, and pieces of an urn.

The investigator had replaced the bones, but parts of the urn were left on the ground, and these were found by Miss Stirling, who gave them to me.

There was evidence that a spade had been pushed into the underlying sand and gravel, but inquiry revealed that no further damage had been done.

Cist and Contents.—A view of the cist after removal of the cover stone is shown (Plate XXXIII.). It was situated near the summit of a mound composed of river gravel (Plate XXXIII.). On the east lay the River Isla, and on the west a tree-covered mound, part of which is seen in the photograph. At Birkhill, not far distant from this site, there is a similar configuration of the ground which was excavated by Lord Abercromby, who found skeletal remains in it.[1]

The sides and roof of the cist were formed by slabs of stone of varying thickness taken from the Lower Old Red Sandstone Series. That on the west was too short to meet the one on the north side, and flat pieces of gravel had been packed in to fill the gap in the corner. There was no slab on the bottom of the cist, only a smooth bed of river gravel.

The measurements taken from the interior of the cist were as follows :—

North side, 3 feet 7 inches ; south side, 3 feet 3 inches ; east end, 1 foot 8 inches ; west end, 2 feet. Approximately two-thirds of the interior of the cist was filled with sand and gravel which had evidently filtered into it during a very long period. On the surface of this gravel there lay exposed a skull, parts of a scapula, pelvis, femur, and vertebrae (Plate XXXIV.). On removing the gravel other bones were found in a soft and badly preserved state. They were carefully removed by hand and dried by the sun and wind.

1—*Proc. Soc. Ant. Scot.*, vol. xxxviii. p. 82.

As few skeletal remains have been described from Perthshire, a hydrogen-ion test of the soil in and around the cist where the skeleton lay was made. This showed the soil to be 6.9 or almost neutral.

A piece of grey flint of triangular section, measuring 22 mm. long and 11 mm. broad, was found lying close to the rib bones. It showed slight working along the edges, as if it had been a saw.[1] There was no evidence of any mineral substances among the gravel.

Pieces of a small cinerary urn with simple line markings were found buried in the south-east corner of the cist. Three large parts of it which lay exposed were light in colour on the outside, and black on the inner surface (Plate XXXIV). Several small portions of the urn were found in the detritus right down to the floor of the cist. Some of these pieces were much decayed and of a brick-red colour on the outer surface. On rejoining these fragments it appeared that the rim was not a true circle. The diameter of the mouth had measured approximately 6 inches. The pieces of the urn, when measured according to the formula of Ludovic McL. Mann in his "Craftmen's Measures in Prehistoric Times" gives the rim measurement as 5.54 inches. A reconstruction based on his Alpha Units gives the height of the urn as 7.428 inches. The markings were in the form of incised horizontal lines separated by a single zigzag pattern. An urn described by Sir William Turner,[2] and several others, 10 to 18 inches in height, found in a cemetery at Kirkpark, Musselburgh, and described by Anderson,[3] bore similar markings.

The pottery of the urn is remarkably coarse in texture, and at my request a microscopic examination was kindly carried out by Mr. C. F. Davidson, F.R.S.E. Mr. Davidson reports that he has examined the pottery in thin sections prepared from fragments previously cooked in Canada balsam, and in a powdered form, under the petrological microscope. It was found that a great many fragments of dolerite from 2 mm. to 4 mm. in diameter were mixed with the clay of the urn. They were of non-ophitic tholeiitic type, similar to certain dykes exposed to-day near Blairgowrie and in other parts of Perthshire, and were almost as fresh as the rocks now quarried. The augite showed no trace of decomposition, and the plagioclase feldspar exhibited Karlsbad and albite twinning.

The variations in colour of the colloidal clay material may be attributed to slight differences in the degree of firing. Mr. Davidson was of the opinion that the fresh angular tholeiite dust was presumably powdered rock from one of the local outcrops, and had been added to the clay, probably obtained from one of the river terraces, to prevent shrinkage in the baking of the urn. In much the same manner to-day, in the Carse of Gowrie,

1—Boyd Dawkins, *Early Man in Great Gritain.*
2—"The Craniology of the People of Scotland," *Trans. Royal Soc. Edin.*, vol. li. p. 195, fig. 8
3—*Proc. Soc. Ant. Scot.*, vol. xxviii. pp. 62-78.

ashes are added to the excavated clays in the process of making bricks and tiles.

My thanks are due to the proprietor of Meikleour Estates and to the factor, Mr. John Renton, for granting permission to examine the site.

Note on Skeletal Remains.

By MARGARET G. L. RITCHIE, L.D.S.

Examination of the skeleton was made in Perth Museum and also in the Anatomy Department, University College, Dundee, under the supervision of Prof. D. Rutherford Dow. The bones of the head were well preserved, but those of the trunk and limbs were incomplete. There were no evidences of either disease or injury before death.

The skull was of the round-headed type, characteristic of the bronze age short-cist people. The external surface was smooth, except for the anterior part of the frontal, which was eroded, leaving the diplöe exposed. The various sutures were well marked and there was no evidence of any senile change in the jaws. This, taken with a survey of the other bones, indicated the skeleton to be that of a woman about 40 years of age, with a stature of 5 ft. 4 ins., using Manouvier's method of calculation. The capacity of the brain, measured with No. 8 lead shot, was 1390 c.c.: Measurements of the skull were made and the indices were as follows:—Total facial, 73.3; Nasal 55.8; Orbital R. 78.9; O. L. 75; Length-breadth 82.6; Length-height 73.7; Gnathic 96.8; Upper facial 42.2

A detailed examination of the teeth revealed that all were present except the left lateral incisor of the maxilla, the alveolar socket of which was filled up with bone; this suggesting that it had been lost during the early life of the woman. The masticating surfaces of the incisors, right canine, and first premolar were flattened; the surfaces of the second premolars and the first two molars were worn obliquely on the lingual side. The third molars were very small. The palatal measurements were—length 43 mm.; breadth 39 mm.; the maxillo-alveolar length 52 mm.; breadth 61 mm.; with indices for palatal 90.6; maxillo-alveolar 112.8.

Measurements of the Maxillary Molars were:—

	Breadth (Lingual to Labial).	Length (Anterior to posterior).
Right Side—		
1st Molar	11.0 mm.	9.5 mm.
2nd Molar	10.5 mm.	9.0 mm.
3rd Molar...	9.5 mm.	8.7 mm.
Left Side—		
1st Molar	11.3 mm.	10.0 mm.
2nd Molar	11.0 mm.	9.7 mm.
3rd Molar...	10.0 mm.	9.0 mm.

The Mandible was complete, the body was thickened on the medial view and gave a strong support for the molar teeth. The chin was protuberant and the genial tubercles prominent. The teeth were all present. The cutting edges of the incisors were flattened. The left canine opposite to the missing tooth of the upper jaw projected above the surface of the others, and together with the adjacent premolar, showed no evidence of wear. The wear on the other premolars and molars corresponded to the wear on those of the maxilla, except that the wear was on the lateral side of the teeth. This gave an indication that the incisor teeth of both jaws met edge to edge while the labial and lateral wear on the surfaces of the molar teeth indicated a backward and forward movement in their use and not the usual side to side motion. Two of the teeth showed evidence of caries. Measurements of Mandible :—Condylo-symph length 96 mm. ; Height at symphysis 28.5 mm. ; Height at second molar (Body) 27.5 mm. ; Height : coronoid 57 mm. ; Height : condyle 64 mm. ; Bicondylar breadth 114 mm. ; Bigonial breadth 88 mm.

Measurements of the Mandibular Molars were :—

	Breadth (Lingual to Labial).	Length (Anterior to posterior).
Right Side—		
1st Molar	10.0 mm.	9.5 mm.
2nd Molar	9.0 mm.	9.5 mm.
3rd Molar...	8.5 mm.	9.0 mm.
Left Side—		
1st Molar	9.5 mm.	9.5 mm.
2nd Molar	9.0 mm.	9.8 mm.
3rd Molar...	8.0 mm.	8.5 mm.

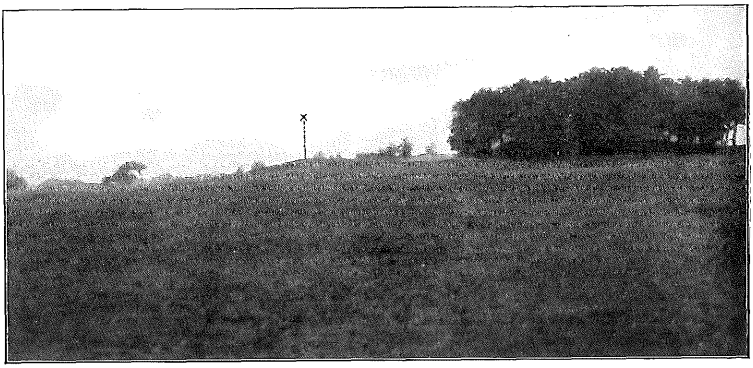
The bones of the Trunk were incomplete, but the following were obtained :—the atlas, the axis, both almost complete ; of the vertebrae there were 5 partly broken cervical, 12 dorsal and 4 lumbar. The sacrum and a small part of the coccyx. Both scapulae were broken, the clavicles were complete, the manubrium was slightly broken ; of the ribs, only the first were complete, the others being in fragments.

The bones of the Limbs :—the shafts of the humeri ; the left radius, complete, fragments of the right radius and of the ulna ; 10 carpal bones ;. 5 metacarpels, and several fragmentary metacarpels and phalanges.

The right femur with a maximum length of 458 mm. was complete ; the left incomplete. The right tibia, although broken into three pieces was complete, but there was only a part of the left found. The whole of the talus, the calcaneus and the patella of the right side were found, also fragmentary pieces of right fibula, metatarsals, etc.

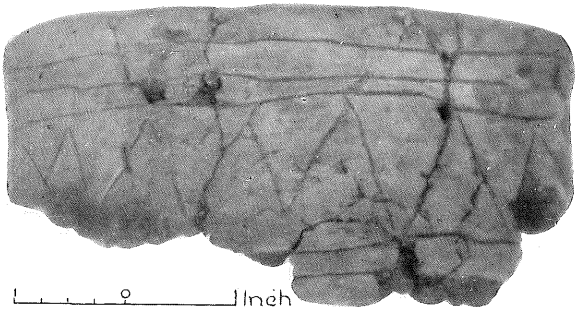
Plates XXXIV. and XXXV. are from photographs of various views of the skull.

View of Cist.



View of Mound. X Marks Site of Cist.

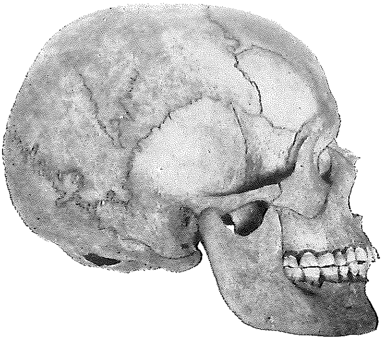
Plate XXXIII.



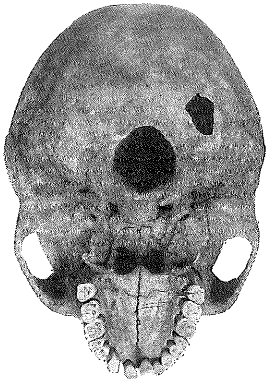
FRAGMENT OF URN.

MAXILLAE SHOWING WEAR ON CROWN OF TEETH.

PLATE XXXIV.

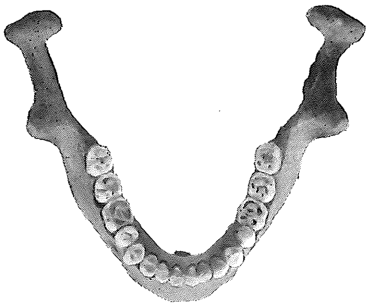


Norma Lateralis.

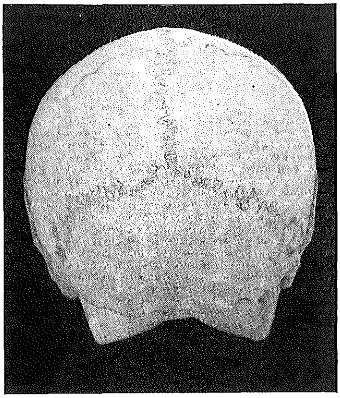


Norma Basilis.

Norma Facialis.



Mandible.



Occipital View.

Norma Verticalis.

Plate XXXV.

XXXII.—The Life Cycle of the Fern.

By EDWARD SMART, B.A., B.Sc., F.R.S.E.

(Read 9th March, 1934).

The subject I have chosen for my annual address is the Life Cycle of the Fern. In recent years there has been a considerable amount of study and research in the various phases of the Life Cycle and I thought it might be of interest to the members of the Society to have a brief account of the present state of our knowledge in regard to it. One of the most outstanding workers in this field of research is Dr. F. O. Bower of Glasgow, and though I have drawn from other sources, it is mainly from his valuable and exhaustive work on Ferns that I have collected the materials for this address.

Ferns may be propagated by both sexual and asexual methods; and though the asexual method is not common, yet with the common bracken and male fern it is of regular occurrence. The rhizome of the bracken sends out shoots which produce independent plants through the withering and decay of the part of the rhizome intervening between the young shoot and the parent plant; and it is by this method rather than by the sexual process that the spread and continued existence of the bracken is secured. In the male fern again, small buds are developed near the base of the leaf stalk and these in time fall to the ground, take root and give rise to new plants in every respect similar to the parent to which the buds were originally attached. In various species of *Asplenium* vegetative reproduction is secured by small bulbs or bulbits which grow on the pinnae of the leaf, and this method of propagation is to be met with in certain other cases where the spore bearing organs, the sporangia, fail to reach maturity. In all these cases, however, the parent plant is normally produced without the appearance of any intermediate product. It is only when we come to the sexual method of reproduction that we meet with what is termed the Alternation of Generations.

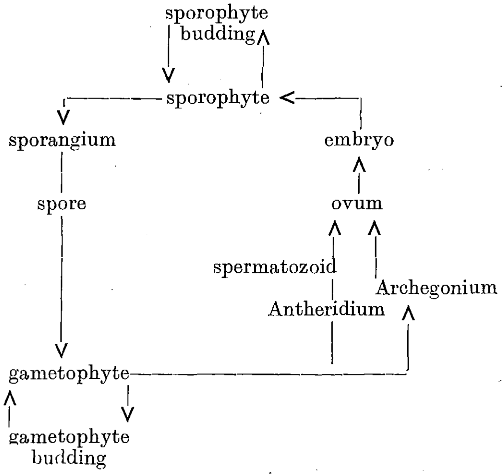
If we examine the underside of the leaf of most ferns we shall usually find small clusters of organs regularly arranged in a pattern which is constant for the species. These clusters are termed *sori*, and consist each of a group of spore-bearing organs, the *sporangia*, with, in most species, a covering or protective structure termed the *indusium*. In very exceptional cases do these sori appear in any other position than in close relation to a vein, usually on a vein-ending—a position which secures for them a steady supply of the nutritive material needed for their growth and development. Confining our attention meanwhile to the male fern *Dryopteris Felix-mas* we see that the sporangium, one of the individuals of the group of sporangia, consists of a neck or stalk with a relatively large bi-convex head encircled by a band or ring of firm walled cells termed the annulus. At one part of the annulus, however, these cells are replaced by thinner walled ones and it is in this area, termed the *stomium,* that dehiscence of the mature sporangium takes place.

In most of our ferns the sporangium is developed by growth and segmentation from a single superficial cell. And in the penultimate stage of development we have a core of 12 spore-mother cells immediately surrounded by two layers of cells termed the *tapetum* and an outer layer forming the boundary and enclosing wall of the sporangium. On further developing the tapetum gets broken up and disappears or becomes fluid so that the interior of the sporangium is now filled with a fluid in which float the 12 spore-mother cells. Each of these 12 mother cells now divides to form 4 spores and as these spores reach maturity the fluid contents of the sporangium are absorbed, the spores themselves become hard and dry and the dehiscence stage is reached. The stomium ruptures, the annulus moves slowly backwards, exposing the spores, the contents of the sporangium, which are thrown out when the annulus having come to the end of its backward movement suddenly regains its initial position—the whole movement resembling that of a spring which is slowly pulled back and then suddenly let go.

The spore consists of an outer firm coating, the *epispore,* and an inner membranous coating enclosing the nucleated *protoplast.* Under suitable conditions of moisture and temperature the epispore bursts and the first stage of the growth of the *prothallus* begins. Pushing aside the ruptured epispore, the prothallus appears first as a filamentous growth, but it gradually expands by continued segmentation and finally, in the particular case we are considering, becomes, under free conditions of growth, a flattened cordate structure attached to the ground by numerous rootlets or rhizoids. At first consisting of a single layer of cells joined together, without intercellular spaces, the area of the prothallus situated centrally and immediately under the emarginate apex, by continued division of its cells in planes parallel to the surface, becomes thicker and more solid ; and it is on this thickened pad of cells that the sexual organs make their appearance. The male organs, the *antheridia,* are formed on the lower part of the prothallus mixed up with the rhizoids, while the female organs, the *archegonia,* occupy a position further up, immediately under the apical indentation. The *antheridium* is developed from a single superficial cell and contains when mature a collection of *spermatocytes*. Unlike the sporangia, which require a dry atmosphere for dehiscence and dispersion of the spores, the antheridia only open in the presence of external water. The rupture of the antheridium, brought about by the pressure caused by the swelling of the spermatocytes through absorption of moisture, opens a passage for the escape of the spermatocytes and these, in turn rupturing, set free the enclosed spirally coiled *spermatozoids* which move about in the water by means of the cilia with which they are provided.

The female organ, the *archegonium*, is also the result of growth and division from a single cell, and in the fully developed state consists of a hollow columnar structure of cells, with the ovum at the base of the canal or hollow interior and above this and in the canal the two *canal cells*. As with the antheridium the presence of water is necessary for rupture of the archegonium, and when the rupture takes place the two canal cells are pushed out or disappear leaving a free passage for the entry of the spermatozoid to the ovum. The spermatozoid does not find its way by mere chance to the ovum, but its behavior clearly shows that there must be some attractive influence which guides it in its path. If a drop of certain dilute solutions (malic acid) be added to the water in which the spermatozoids are moving about they will move towards it. And it is now established that an emanation of a similar character coming say from the canal cells or perhaps the ovum itself, exercises this attractive influence. The union of the two sexual elements is followed by a complete fusion of the contents of the two cells—not only do the nuclei fuse together to form one nucleus, but the extra-nuclear or protoplasms of the two cells also get completely mixed together. It is also a remarkable fact that only one spermatozoid is required to fertilise the ovum. Immediately on the entry of the spermatozoid to the ovum some remarkable change takes place so that the ovum ceases not only to be a source of attraction for other spermatozoids, but is actually poisonous to them. This is the case for both plants and animals. The nature of this change has been observed in the case of the sea-weed *Halidrys siliquosa*, where the entry of the male element is immediately followed by a roughening or crinkling of the ovum. If by any chance this reaction is slowed down or delayed, a second spermatozoid may enter the ovum; but it seems to be established that in such a case further development is either arrested, or if it does continue a "monstrosity" will be produced. The cell resulting from the union of the spermatozoid with the ovum is termed the *Zygote* and it immediately begins to produce the embryo plant. Emerging from the archegonium the cotyledon and the first root make their appearance nourished by the nutriment content of the prothallus which gradually disappears as the roots and leaves of the young plant develop.

The following diagram shows the phases of the whole life cycle.



The diagram shows that the prothallus or gametophyte and the sporophyte or fern plant may produce themselves by budding—the sporophyte bud giving a sporophyte and the gametophyte bud giving you the prothallus or gametophyte—the sexual process alone giving the complete life cycle or alternation of generations.

The diagram, of course, does not show that the sporangium requires a dry atmosphere for the discharge of its function and the prothallus moisture and water. Bower says the life cycle may not be inaptly described as amphibious since the one phase is dependent on external water and the other is independent of it.

Associated with the phases of the life cycle there are certain changes in the nucleus of the cells to which a good deal of attention has been given with the view of ascertaining whether or not the one was a necessary accompaniment of the other.

Before 1875 there was very little exact knowledge of the changes that take place in the cell or cell-division, and it was only in that year that Eduard Strasburger, professor of Botany at Bonn, made known to the scientific world in his publication *Zellbildung und Zelltheiling* the result of his researches in that connection. Then for the first time were the complicated and important processes in cell-division clearly understood. In an ordinary resting nucleus there is a fine network of material whose presence can be detected by suitable staining. This material is known as *chromatin.* As cell division approaches this chromatin assumes the appearance of a more or less coiled up thread, the *spireme*, which breaks up into separate filaments, termed *chromosomes*, and it is a curious fact that the number of chromosomes is constant for every species of plant or animal. The next stage in the process is the assembling of the chromosomes along the equatorial plane of the cell in which in the meantime have appeared curving streaks of chromatin in the form of a spindle of fibres and stretching from pole to pole of the cell. The chromosomes now split along their length and the twin halves pass in opposite directions along the fibres of the spindle, collect at the opposite ends, or poles, of the spindle and, becoming invested by a fine membrane, form two daughter nuclei. In the protoplasm between the two daughter nuclei and along the equatorial plane a partition appears and thus the original cell is divided into two independent cells. Now the condition of the nucleus in the various stages of the life cycle has been observed by Yamanouchi and others. In the sporophyte, or fern plant, the number of chromosomes in the Male Fern is 128, which is the *diploid* number and this number is retained in cell division until we come to the tetrad division of the spore-mother cells, when the number of chromosomes becomes, by a process of reduction or *meiosis*, 64, which is the reduced or *haploid* number. In view of what has already been said it is difficult to understand why the original number should thus be halved, but somewhere in the cycle of all sexual processes there occurs an unique kind of nuclear division in which the chromosomes instead of remaining separate and finally dividing, first of all unite in pairs. The result of this of course is a reduction to one half of the number originally present. Each pair now behaves exactly as a single chromosome and thus when the two daughter nuclei are formed in the usual way each daughter nucleus will have only half the number of chromosomes that there was in previous nuclear divisions. Probably the pairing of the chromosomes is of the nature of sexual pairing, the individuals of the pair being respectively of male and female origin.

The tetrad spores with the reduced number of chromosomes produce the gametophyte, or prothallus, which is consequently also haploid. The fusion of the gametes of the prothallus naturally doubles again the number of chromosomes and the young plant, the sporophyte, is this diploid. It has been definitely established that when we have the sexual method of propagation the alternation of sporophyte and gametophyte is always accompanied by the changes referred to in the nuclear content of chromosomes.

Our knowledge of the life history of the fern, the normal phases of which in respect of the Male Fern have now been described, is of comparatively recent date. As the name *cryptogam* shows, it was at first supposed that seeds were produced, but that the seeds and the whole mechanism of production were hidden from observation. Before the nineteenth century there had been some suggestions by early observers, but the first real step towards the solution of the mystery was made by Carl Nageli in 1844, when he discovered the antheridia and the spermatozoids. The small leaf-like bodies which were often to be found on moist ground in the neighbourhood of ferns had been generally regarded as cotyledons, and it was in these small structures that Nageli discovered free swimming spiral objects. These were, however, only recognised as the male elements when Wilhelm Hofmeister in 1851 made known the results of his research in the publication, *Vergleichende Untersuchungen.* In this work he described the development from the spore to the prothallus, the formation of the antheridia and archegonia, the fertilisation of the ovum by the spermatozoid and, as the result of the union, the fern plant. Since then much research work has been done and valuable contributions to our knowledge have been made, especially by Professor Bower.

Coming now to compare in different species the organs associated with sexual reproduction we find remarkable differences. We have seen that the sorus of the Male Fern includes a group of sporangia, but the simplest form of sorus consists of only one sporangium, such as we find in *Botrychium* and *Ophioglossum.* In *Botrychium* the sporangia are borne in two lateral rows on a spike, each sporangium being separate and distinct from its neighbours. In *Ophoglossum* the sporangia coalesce and form a distichous synangious spike—the bases of the sporangia being sunk in the surrounding tissue. In these species the sporangium is a relatively stout structure which requires no indusium for protection. These ferns Bowers classifies with the Osmundaceæ and others, mainly tropical, as *Simplices,* because he considers them of a primitive type closely related to certain fossil forms.

The second type of sorus is the *Gradate* or *basipetal* sorus. It consists of a more or less columnar receptacle upon which the sporangia are seated—the first and oldest sporangia are at the top, or destal end of the column, and there is a gradual succession downwards, the youngest being at the base of the column. To this class belong, among others, the *Hymenophyllaceæ,* of which we have in Britain three species. In those the sporangia are sessile on a club shaped receptacle surrounded by a two-valved or cup-shaped indusium and the annulus is oblique, a device which, under the circumstances of their setting, favours the scattering of the spores. Ferns possessing such sori occupy a middle position between the more modern species and the *Simplices,* and are related to fossil forms of the Mesozoic Period.

But the great majority of modern ferns possess the type of sorus called "mixed." Here there is no regular successive production of sporangia, but the young and the old are mixed indescriminately together. The necks, or stalks, of such sporangia are usually long and slender and the annulus vertical.

The position and form of the sorus on the leaf are, as a rule, constant for every species and often furnish the key to its identification. Generally with the *Simplices* the sporangia occupy a distal or marginal position on the leaf, while the position in most modern types is dorsal and there is good evidence from the story of their descent from ancient fossil forms that in the course of evolution the sori have gradually shifted their position from the margin to the surface of the spore-bearing leaves. Bower quotes Professor von Goebel as stating " that the more the sporophyll is developed as a dorsi-ventral foliage leaf the more are the sporangia restricted to the lower surface." This conclusion is strengthened by the fact that the sporophylls of ferns with marginal sori are relatively narrow (e.g. Blechnum) while those of the Marattiaceæ, the Gleicheniaceæ, the Matonineæ, tropical species and more or less closely related to early fossil forms, are broad and have their simple sori superficial. And there is further evidence, which cannot be given in this short paper, to show that the superficial position of the sori has been acquired as a consequence of the increase of surface of the sporophyll. An interesting feature to be found in some tropical species, where there has been a large increase in the leaf surface, is the splitting up of the sori into parts so that there is an apparent increase in the number of individual sori. But, besides this splitting up we also meet with fusion when the sori become fused together to form *fusion*, or *coenosori*. We have examples of this in the Bracken and Hard Fern. Again, in *Scolopendrium* we meet with a further development where the original continuous line of the coenosori has been broken up and the sori form a series of bands on either side of the midrib—due again to the broadening of the leaf surface.

A remarkable departure from the normal position of the sori on the veins is to be found in the *Acrosticheæ*, where the sori are distributed all over the leaf surface, on the mesophyll as well as on the veins—a peculiarity which none of our British ferns possess.

We have seen that in the primitive ferns, the *Simplices*, to which belong our Moonwort, Adder's Tongue and Royal Fern, the sporangium is a relatively solid structure and unlike the sporangium of our modern types, which is, by comparison, a delicate structure. This difference finds its explanation in the development of the former, termed the *Eusporangiate*, from a group of cells, whereas in the latter, the *Leptosporangiate*, the development is from a single superficial cell. The more delicate structure of the sporangia of the Leptosporangiate ferns have therefore need of some kind of protection, such as is afforded in many species by the indusium. Though amongst the *Polypodiaceæ* we find in certain species no indusium, yet the close packing of the sporangia and the presence of hairs probably give all the protection necessary. The indusium may arise as a superficial growth, or it may be, as in *Blechnum*, a simple folding over of the margin of the leaf. In that rather strange fern, *Ceterach*, the narrow ridge on the nerve probably represents the vestigial trace of an indusium, but the scales under which the sori are concealed give good protection. Though both types of sporangia are to be found in our British ferns, yet the evidence of Palaeontology, according to Bower, shows decisively that the Eusporangeate were the first to be developed and that there was a gradual progression to the Leptosporangiate in which the sporangia, though smaller and more delicate, are, at the same time, better adapted for the scattering of the spore.

The flattened cordate type of prothallus already described is the commonest type of prothallus for leptosporangiate ferns, but there are various forms, and even the type described may, through malnutrition, not emerge from the filamentous form with which the prothallus commences its growth. And the filamentous form is the normal structure of gametophyte with the Hymenophyllaceæ and the Schizæa whose only representatives with us are the Filmy Ferns. The filaments, consisting of rows of chlosophyll-containing cells, bear the antheridia and the archegonia, while the presence of fungal filaments amongst the tissues of the filaments in contact with the ground seems to mark a stage towards the next type of prothallus, which is a saprophyte and consists of a subterranean mass of tissue containing no chlorophyll and a part above the ground which carries the sexual organs. This type of prothallus is characteristic of the Ophioglosseæ to which class belong the Adder's Tongue and the Moonwort.

These three types of prothallus are the structures connected with the normal method of reproduction by sexual processes, and I have already referred to the vegetative reproduction of sporophyte and gametophyte from sporophyte and gametophyte buds respectively. But there are deviations from the normal and many cases of extraordinary irregularity in the sexual cycle have been observed by many observors. These irregularities or abnormalities are of two kinds (1) *apospory*—the condition when no spores are produced and the gametophyte is developed from the sporophyte by a purely vegetative process; (2) *apogamy*, or *apomixis*—where there is no union of male and female elements and there is a vegetative transition from gametophyte to sporophyte. Thus Farlow in 1874 obtained the sporophyte from buds on the prothallus of *Pteris cretica*. Apospory was discovered by Druery in 1884, and has been carefully examined by Bower, who found that the features of the two generations of gametophyte and sporophyte were "liable to be mixed up in the most perplexing fashion." A few of these irregularities may be mentioned:—in *Nephrodium pseudo-mas* variety, *Aristatum*, a sporophyte, was found to have been produced apogamously and on the margins of the first leaves of the sporophyte aposporous prothalli appeared. Sporangia were observed by Lang growing on the prothallus of

Nephrodium dilatatum with numerous archegonia on its base—and there are many examples of other irregularities.

Naturally, the chromosome content in these irregular cases has also been the subject of careful examination. Probably the simplest case is that of the apogamous *Nephrodium pseudo-mas* var. *polydactylum.* A careful examination of this case made by Farmer, Moore and Miss Digby revealed that in the young prothallus there was a fusion of the nuclei of two neighbouring cells and that this apparently constituted an irregular sexual process for there followed the doubling of the number of chromosomes. The fern produced showed the usual meiosis or reduction of the number of chromosomes in the spore-mother cells and then the development of the haploid prothallus. But though the normal chromosome relation has been observed in this case, there are many cases which seem to baffle every attempt to find a relation between the irregularities and the chromosome content. Thus Farmer and Miss Digby found that *Athyrium Felix-foemina* var. *clarissima* is deploid in all its phases. Fertile prothalli were produced from the sorus, but there was no fertilisation nor migration of nuclei and the fern was produced from a diploid apogamous bud. There are other and similar cases of the phases being deploid throughout which need not be mentioned. These two observers then endeavoured to find if there were cases where the phases were haploid throughout and this they appear to have found in the case of *Lastrœa pseudo-mas* var. *cristata apospora* Druery. Yamanouchi found a similar condition for *Nephrodium molle*, while Steel found that for *Nephrodium hirtipes* Hk., while the prothallus was produced from haploid spores, it bore no archegonia and the sporophyte arose as a vegetative growth from the prothallus, the reduced, or haploid, number of chromosomes being retained.

The result of these and other observations show that the gametophyte may be diploid, though it is normally haploid, and that the sporophyte may be haploid, though it is normally diploid. The external appearance of the generations is unaltered and thus there seems to be no essential relation between the chromosome cycle and the alternation of generations. We must not forget, however, that where the sexual process has been carried out and union of the male and female elements has occurred, *meiosis*, or reduction of the chromosome number is always a feature of the life cycle.

I cannot go further into this for I feel that my paper is already too long and I must refer you for a fuller treatment and possible explanation of these irregularities to Professor Bower's great work on Ferns.

XXXIII.—Plant-hunting on Ben Ledi.

By JAMES AITKEN.

(Read 8th February, 1935).

While staying for a short holiday at Callander last year, I went on many plant-hunting rambles up the gullies and hillsides in the neighbourhood. The most interesting, and possibly the most fruitful of these rambles took place on the slopes of Ben Ledi, which a friend and I one day set out to climb.

We took the Lochearnhead bus to the Falls of Leny, and crossing the river by means of the railway bridge, started up the steep south-eastern slopes of the mountain.

The going was very rough to begin with, as we had to force our way through a deep belt of bracken. On many occasions my friend, who is not very tall, could only be detected by the waving fronds. However, we soon got above the belt, and while crossing a stretch of moorland we came upon a boggy hollow, bespangled with the elegant flowers of the Grass of Parnassus (*Parnassia palustris*) and the bog Asphodel (*Narthecium ossifragum*).

These beautiful plants can easily be grown in some moist spot in the garden, or failing this, to dig in sphagnum moss round the roots of the plants will be found satisfactory.

A very steep climb by the side of a small stream now confronted us. We frequently stopped to rest on the way up, and at each stop were always tempted to eat some of the provisions which we had brought with us, and I believe the thought of this largely occupied the mind of my friend between the stops.

At last we came to the more alpine flora of the mountain, for by the side of the stream hung large mats of the mountain saxifrage (*Saxifraga œizoides*) covered with its bright yellow flowers, spotted with scarlet. In the crevices of a low cliff nearby grew some plants of *Sedum Rhodiola*, sometimes called rose-root, as its thick woody root has a scent which resembles that of the rose.

The mountain-side at this part was covered by large tracts of scree, through which flowed abundant moisture from the higher ground. Here in the moist stone chippings many alpine plants found an ideal home.

One small and interesting plant growing here was the Fir Club-moss, *Lycopodium Selago.* The club-mosses and horsetails or Equisetums of to-day are the humble descendants of a race of plants which dominated the world at a time when our coal deposits were being formed. They must have grown to a great height, as fossil remains have enabled botanists to state positively that these club-mosses were not uncommonly one hundred feet high.

But as the moist steamy conditions which prevailed during the coal age no longer exist, the giants have gradually dwindled and died down, till only the small club-mosses, which we know to-day, remain, and inhabit moist places in mountainous districts.

The name Club-moss is rather misleading, as these plants are not true mosses, but are more related to the fern tribe as far as their construction and reproduction goes.

On the short turf nearby we found the well-known "Stag-horn moss" (*Lycopodium clavatum*) and also the small alpine club-moss (*Lycopodium alpinum*). Both were bearing large numbers of their "clubs," which are the spore-bearing bodies, and which give the plants their common name, club-moss.

From the "clubs" of these plants a yellow dust is given off, which is highly inflammable, and has been used in the making of fireworks, and also to produce the effect known as stage-lightning.

Another plant which we came across was *Selaginella spinosa.* It is related to the Lycopodiums, and is the only British representative of a vast genus, numbering nearly three hundred species of stove, greenhouse, or hardy plants.

In appearance Selaginella spinosa is like a thin and slender club-moss. Its evergreen shoots are about two inches high.

Climbing steadily upwards, we eventually came to an extra steep part of the mountain, where the stream tumbled down between rocks and boulders. Here we lay in the sun to rest for a while, and to admire the wonderful view which we obtained from this high point. Loch Lubnaig lay like a pool of silver far below, while the River Leny wound its way down the pass towards Callander.

In the short grass on which we lay grew both the blue and white varieties of *Polygala vulgaris.* This plant is commonly called milkwort, owing to the milky juice held in the root. I also noticed a large patch of the mountain everlasting, *Antennaria dioica.*

We spent a long time scrambling about the steep slopes at this part, and discovered that low alpine shrub known as the crowberry (*Empetrum nigrum*).

This plant has very small evergreen heath-like leaves, and grows to a height of about six inches. The flowers are asexual, that is, bearing the male and female flowers on separate plants. The berries produced are black in colour, and are about the size of a pea. The fruit is much eaten by moor-fowl, a fact which probably gives the plant its popular name, crowberry.

My friend, who is not, and does not pose to be a botanist, was at first only politely interested in my discoveries, but I was delighted to see him now scrambling about searching for new varieties of plants as keenly as myself.

The plant which seemed to take his fancy more than any other was the Butterwort or *Pinguicula vulgaris*, which grew in abundance in all the moist places. The plant has been used to curdle milk, hence the name Butterwort.

The pure mountain air seemed to give us extra vigour, and up the steep rough slopes we toiled. Blaeberry bushes now covered the ground like a dense green carpet, but to my friend's concern very little fruit could be found on the plants.

However, while we were earnestly engaged in hunting for berries, a plant was noticed bearing bright red fruit. On examination this turned out to be the Cow-berry, *Vaccinium Vitis-idaea.* (The name from Vitis-vine and Idaea after a mountain in the island Ida in the Mediterranean :—the vine of Mount Ida.)

The plant closely resembles the blaeberry, being similar in height and appearance, and if it was not for the colour of the fruit, might easily be mistaken as such.

Coming eventually on to a level shoulder of the mountain, we again paused to rest and to take stock of the surroundings.

In a moist hollow I was delighted to find a clump of *Rubus Chamaemorus*, the mountain bramble. It is a herbaceous plant about three inches high, and bears solitary flowers about one inch in diameter. The fruit is large in comparison with the plant, and is orange-yellow in colour. The popular name of Cloudberry has been given to the plant, owing to its natural home being high up in the mountains amongst the clouds.

Meanwhile time was getting short, and we wanted to catch the last bus back to Callander, so, having collected specimens of all the plants mentioned, we prepared to descend.

XXXIV.—A Boring at St. Fort, Fifeshire.

By CHARLES F. DAVIDSON,
St. Andrews University.

Read 8th February, 1935.

The wide expanse of fluvioglacial and glacieluvial sands and gravels extending from north-west of Leuchars railway station to the neighbourhood of Wormit, in Fifeshire, is well known to geologists, and has been the subject of numerous contributions to geological literature, the most important of which are the following :—

R. Chambers ...	...1867	"Notice of an 'Eskar' at St. Fort, Fifeshire." Geol. Mag., vol. iv., pp. 549-50.
J. Durham... ...	...1877	"The Kames in the Neighbourhood of Newport, Fife, N.B." Geol. Mag., Dec. 2, vol. iv., pp. 8-13.
Sir A. Geikie ...	...1901	"The Scenery of Scotland." 3rd Edn., p. 488.
Sir A. Geikie ...	...1902	"The Geology of East Fife." Mem. Geol. Surv. Scot., pp. 289, 296-301, 311-12.
J. W. Gregory ...	...1926	"The Scottish Kames and their Evidence on the Glaciation of Scotland." Trans. Roy. Soc. Edin., vol. liv., p. 407-08.
J. K. Charlesworth	...1926	"The Readvance Marginal Kame-moraine of the South of Scotland, and Some Stages of Retreat." Trans. Roy. Soc. Edin., vol. lv., pp. 42-46.
J. F. Scott ...	...1929	"Notes on the Glacial Geology of the Fife District." Proc. Geol. Soc. Glasgow, pp. 623-624.

Although much work has yet to be carried out on the derivation of the gravels and boulders of these deposits, the present writer does not presume to add to this already extensive literature. He is privileged, however, to place on record a bore through the glacial deposits, made for the Scottish Sand and Gravel Company at St. Fort, Wormit, during the spring and summer of 1934.

Acknowledgments are made to this company, and to their manager, Mr. J. S. Gordon, for permission to publish the bore record.

The rocks penetrated by the boring are as follows :—

Strata	Thickness of Beds		Total Depth		
	Ft.	Ins.	Fthms	Ft.	Ins.
Sandy Clay and Gravel ...	10	...	1	4	...
Coarse Gravel...	8	...	3	...	...
Boulders	4	...	3	4	...
Coarse Gravel...	2	6	4	...	6
Gravel	2	6	4	3	...
Coarse Gravel...	3	...	5	...	...
Boulders and Gravel	9	3	6	3	3
Gravel	2	9	7	...	...
Coarse Gravel...	3	6	7	3	6
Bound Gravel	12	6	9	4	...
Red Sandy Clay with Boulders	33	...	15	1	...
Bound Gravel	1	...	15	2	...
Boulders and Broken Rock	3	...	15	5	...
Broken Rock	1	8	16	...	8
Gravel	19	4	19	2	...
Coarse Gravel...	2	...	19	4	...
Bound Gravel	11	6	21	3	6
Loose and Coarse Gravel ...	3	...	22	...	6
Whin (Old Red Sandstone Andesites)	109	9	40	2	3

The boring is of considerable interest, as until now no satisfactory estimation of the thickness of these glacial deposits has been made. The sands, gravels, and clays penetrated in the bore have a thickness of 22 fathoms, 0 feet, 6 inches (132 feet, 6 inches). The surface is about 80 feet above sea level, and the gravel hills sixty yards to the west rise to 160 feet. The total thickness of glacial deposits may be estimated therefore at about 210 feet; the original thickness must have been considerably greater, as the extent of the sands and gravels has been much reduced by post-glacial denudation.

All the sediments examined from the boring show a close resemblance to the fluvioglacial and glacieluvial deposits occurring in the neighbouring gravel pits, and there is no indication that any of the beds penetrated have accumulated under marine conditions. It is of interest to record that the gravels lie directly on top of the solid rocks, both boulder clay and shelly marine clay being absent. There are thus no grounds for the statement of Sir Archibald Geikie (op. cit.) that the "kame" deposits are of later date than the hundred foot beach, for in that case one would expect to find the gravels resting upon a basement of arctic clays similar to the deposits at Errol*.

The glacial deposits are seen to overlie slaggy Lower Old Red Sandstone andesitic lavas, in a very decomposed condition, similar to the rocks which outcrop near Newton Farm, a quarter of a mile to the S.S.E., and in the hilly ground less than a mile to the north. The gravels thus appear to fill up a prominent depression ("the Wormit gap"), the floor of which is, locally at least, between forty and fifty feet below sea level. This pronounced valley feature is probably a glacial channel carved out by a tongue of the main mass of ice descending the Tay valley, which flowed over the N. Fife hills to join the sea ice in the direction of Leuchars.

* C. F. Davidson, "The Arctic Clay of Errol, Perthshire." Trans. P.S.N.S., vol x, part ii, pp. 55-68, pl. xiii-xvii.

XXXV.—*Nova Herculis*, 1934.

By CYRIL WALMESLEY, A.M.I.C.E., M.I.W.E.

This "New" star was discovered by Mr. J. P. M. Prentice, at Stowmarket, in the early morning of December 13th, and its discovery was announced in the wireless news bulletin on the evening of the same day.

At the time of its discovery it had attained a brightness of 2.9 on the stellar magnitude scale.

In view of the appearance of this star, it was particularly apposite that at the Meeting of the P.S.N.S. which took place the following day, the subject of Dr. Rutherford's lecture should have been "The Making of New Stars."

Owing to weather conditions, the writer did not see this star until the evening of December 17th, when, returning home from the office about 5.30 p.m. he noticed in a small clearing in the sky, three brightish stars, two of which he identified as Beta and Gamma Draconis, but the third of which was unfamiliar. This third star seemed a little less bright than Gamma Draconis, say about magnitude $2\frac{1}{2}$. It was, however, but a passing glimpse, and not much reliance can be placed on this estimate.

According to reports published in "Nature," the magnitude of the Nova rose to 1.3 on December 23rd, when it would be about as bright as the star Regulus.

It may be mentioned here that a change of one magnitude implies a $2\frac{1}{2}$ fold change in brightness, so that a second magnitude star is $2\frac{1}{2}$ times as bright as one of the third magnitude and a first magnitude star like Capella is 100 times as bright as one of the sixth magnitude, which is the faintest visible to good eyesight without optical aid.

During the next three days the Nova faded to magnitude 3.4, and then suddenly blazed up to 2.6 on December 27th.

The Spectrum of the Nova is reported to have varied in character with the fluctuations of the star's brightness, showing bright lines and bands due to incandescent hydrogen, helium and ionised metals, especially at times when its brightness was diminishing.

On December 20th, before its maximum was reached, the spectrum was reported to be identical with that of Alpha Cygni, while on December 23rd the only conspicuous bright line was the red H.alpha line of the hydrogen series.

By December 30th the continuous spectrum had nearly faded out, leaving one of bright lines.

It was not until December 29th that the writer had an opportunity of seeing this star in a clear sky, when, on comparing its position with a star chart it was seen that no star of that brightness was indicated on the map.

A three inch telescope, armed with a small direct vision spectroscope was then brought to bear upon it. It only needed a glance at the spectrum to set at rest all doubt as to the identity of the star, for it was one characteristic of novae.

The spectrum appeared faintly continuous with three broad bright bands superimposed. Of these, the most conspicuous was a very bright one in the blue-green region. Another was judged to be in the indigo or blue indigo region and a third was glimpsed in the green.

The first two bands were probably H.beta and H.gamma lines of the hydrogen series, the third may possibly have been due to magnesium. With such a small instrument, however, it is difficult to locate even approximately the position of the lines, a difficulty which was not diminished by the unsteadiness of the atmosphere.

The Star on this date was of a bluish-green hue and was estimated as equal in brightness to Beta Draconis, i.e., magnitude 3.

On January 13th, 1935, a glimpse of the Nova was obtained about 1 a.m. It had brightened up and was judged as about equal to Gamma Draconis (magnitude 2) and a similar estimate was made on January 14th between 8 and 9 p.m. On this date the spectrum was again observed, though with some difficulty, owing to the low altitude of the star. A bright line was glimpsed in the blue (probably H.beta) and one rather uncertainly in the green. It is thought that there were two or three bright lines between these two, and another line was suspected towards the violet end of the spectrum. The lines appeared less bright and narrower than on December 29th.

On January 15th, at 7 a.m., the Nova was high up in a clear sky and its brightness was midway between that of Gamma and Beta Draconis, i.e., was about magnitude $2\frac{1}{2}$, and at 11.30 p.m. on January 22nd it was judged to be of the same brightness.

On January 30th, however, it appeared to have diminished in brightness, but owing to haze one could not be very sure.

On February 2nd at 6.45 p.m. the Nova was seen to be decidedly fainter and was estimated as lying in brightness between Beta and Xi Draconis, i.e., to be of magnitude $3\frac{1}{2}$.

Six hours later, at 1 a.m., on February 3rd, when the star was at a good altitude, it was estimated as brighter than Iota Herculis and equal to Xi Draconis and so of 4th magnitude.

By February 6th at 7 a.m. it had blazed up again to 2nd magnitude, an increase in brilliance more than six-fold in three days !

On February 14th, at 7 p.m., the Nova was glimpsed at intervals through clouds and haze. It appeared brighter than Iota Herculis and fainter than Beta Draconis (i.e., about mag. 3). The spectrum could only be made out with difficulty. Three or more bright lines on a continuous background were noted between the green and indigo, those of shorter wavelength being the stronger.

On February 16th, at 11 p.m., the Nova was noted as intermediate in brightness between Iota Herculis and Xi Draconis (i.e., mag. $3\frac{1}{2}$). Spectrum continuous, crossed in green and blue-green by bright and dark bands. The dark bands were thought to be on the more refrangible side of the bright ones, but only a general impression could be obtained owing to the faintness of the spectrum in so small an instrument.

February 21st, Nova equal to Iota Herculis, magnitude 5. On February 25th, at 10 p.m. the Nova was equal in brightness to Beta Draconis. Its spectrum was continuous, with a bright line in the blue-green and one in the green. A fainter one was glimpsed between these. The line in the blue-green was the brightest and most sharply defined. No dark bands seen.

On March 4th, the Nova had faded again to the brightness of Iota Herculis, and it was still of this magnitude on the 24th of that month, at 11 p.m.

At 9 p.m. on the following day it was only as bright as 30 Draconis, or perhaps slightly brighter, and was just visible to the naked eye.

On March 31st and April 1st the Nova was judged to be equal to, or slightly brighter than, a 6th magnitude star in Hercules, just to the south of the new star at about 18h 5m, plus 41½ degrees.

This is the last observation the writer was able to obtain of this most interesting object.

The Nova has been identified with a very faint star of magnitude 15.4 (only visible in a very large telescope) shown on the Franklin Adams Photographic charts.

At the time of its maximum brightness it had therefore blazed up to 400,000 times its original lustre and since that time it has fluctuated 40 fold in luminosity.

One wonders what adjectives a film Publicity Agent would apply to this cosmic drama if this variety of star engaged his attention !

It seems probable that the star is not so distant as it was at first thought, and a recent estimate places it 200 light years away. (The distance of the sun is a little over 8 light *minutes*.)

If this estimate is near the mark, we are now witnessing a cataclysm which occurred in the 18th century, the light of which has just reached us.

Note added January, 1936.

The following is taken from "Whitaker's Almanack" for 1936 :—

> "There was a comparatively slow diminution of brightness with considerable fluctuations to magnitude 5 at the beginning of April and then a precipitous fall during that month to magnitude 13 at the end. There was then an unexpected, but somewhat slower, recovery and, neglecting minor variations, it may be said that the Nova was of magnitude 9 at the end of May, magnitude 8 in June, and of magnitude 7 from July until October and later, its colour having developed to a vivid emerald green in September. The rapid decrease of light in April and subsequent increase is unusual and paralleled by only one previous phenomenon of this class. There have been also remarkable changes in its spectrum and some observers have noted that the star is made up of two components."

VOL. IX. PART VI.

CONTENTS.

XXXVI.—THE BIRDS OF ATHOLL.

By H. RINGROSE JACKSON.

ABSTRACT.

This paper has been compiled from the personal observations of the late Mr. J. D. M'Kechine, F.Z.S., M.B.O.U., Mr. Donald Ferguson, Blair Atholl, and Mr. Kenneth Burns, Woodend, Blair Atholl, and the author, extending over the period from 1900 to 1935.

Two months only are covered, namely, May and June.

The ground explored is roughly within a line drawn from Killiecrankie up Glen Girnaig to Loch Valican, thence due north to the Ben-y-Ghloe Hills and down to Forest Lodge in Glen Tilt, thence a westerly line between Beinn Dearg and Bein-a-Chait to Loch-an-duin and to Glas Mheall and Chaorvin and Sgaineachmhor, then due south and past the southern end of Loch Garry and almost due east to Loch Choin, thence south and down the Choin Water to Trinafour and Auchleeks in Glen Erochy. The line now passes the east end of Loch Rannoch and follows the road east to Tummel Bridge Hotel, and thence, on a line a trifle south of Loch Bhaic, south again to Loch-na-Leathain past Fincastle and so across to Killiecrankie.

No observations have been made on Tummel side, but the Pass of Killiecrankie and Falls of Tummel are included.

During the period under consideration, new records of birds having visited the district are detailed subsequently: the Wryneck and Pied Flycatcher, on a visit only; also the Great Spotted Woodpecker and the Stonechat, to stay and nest. I was successful in obtaining photographs of most of the birds and their nests, and prepared lantern slides of many of these.

In my list the English names of the Birds are in alphabetical order, and the scientific names follow the list compiled by the British Ornithologists Union of 1883.

We wish to express our thanks to the proprietors and their factors, who so kindly allowed us the run of their estates.

THE BIRDS OF ATHOLL.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
1.	Blackbird.	Turdus merula.	Common.	April-May.	——
2.	Blackcap.	Sylvia atricapilla.	Unknown in area.	——	2 or 3 Pairs in Pitlochry, 1912.
3.	Bullfinch.	Pyrrhula europœa.	Frequent.	May-June.	N. Black Island Wood, Blair Atholl. Lude Lodge Plantation. On face of Sheirglass Hill.
4.	Bunting, Reed.	Emberiza schœniclus.	Rare.	June.	N. Loch Choin. Loch Moraig.
5.	Bunting, Snow.	Plectropanes nivalis.	Not located.	——	Reported on higher hills.
6.	Bunting, Yellow.	Emberiza citrinella.	Common.	20th May to 10th June. Average clutch, 4.	N. Railway embankment. Black Island Wood. Blair Golf Course. Wood End. Bhaic Water. Glen Erochy. Lude House Drive.
7.	Capercaillie.	Tetrao uragallus.	Frequent.	21st to 27th May.	N. Fincastle Woods. Black Island Wood. Woods at Falls of Bruar. Woodside. Fair Bhuidhe.
8.	Chaffinch.	Fringilla Cælebs.	Common, but not on high ground.	May-June.	N.
9.	Coot.	Fulica atra.	Rare, 4 to 5 nests only.	May-June.	N. Loch Moraig.
10.	Cormorant.	Phalacrocorax carbo.	Not nesting.	——	May and June, 1934, visited Loch Moraig spasmodically.
11.	Corn Crake.	Crex pratensis.	Decreasing rapidly.	1935, only 1 pair nested.	N. Near Killiecrankie.
12.	Crake, Spotted.	Poranza maruetta.	——	——	One dead specimen found near Blair Atholl.
13.	Creeper.	Certhia familiaris.	Common in valley.	May-June. Double brooded.	N. Black Island Wood. Tilt Wood.
14.	Crossbill.	Loxia curvirosta.	Rare, spasmodic.	May-June.	N. 1912. Feeding young, Fender Bridge. 1924, Numerous families over wide area.

N.=Every Bird actually found nesting in the area.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
15.	Carrion Crow.	Corvus corone.	Frequently interbreeds with Hooded Crow.	Resulting eggs larger than pure Cornix, and clutch, 5-6.	N. Lude House. Black Island Wood. Loch Moraig. Bhaic Water. Glen Tilt.
16.	Hooded Crow.	Corvus cornix.	——	Clutch, 4-5.	N. Above Forest Lodge, Glen Tilt. Tulach Hill. Choin Water.
17.	Cuckoo.	Cuculus caurorus.	Common.	Eggs in nests of Meadow Pipits; never found in Tree Pipit's nest, but once in Twite's.	N. Tulach Hill. Glen Erochy. Loch Moraig.
18.	Curlew.	Numenius arquata.	Formerly rare, recently increased.	14th to 20th May.	N. Loch Moraig. Loch Choin. Moor above Milton of Invervack.
19.	Dipper.	Cenclus aquaticus.	Common.	30th April to 11th May.	Bhaic Water. Banvie. Rivers Tilt and Garry. Valican Water. Choin Water.
20.	Diver, Black throated.	Colymbus arcticus.	Rare 1908-1920, since disappeared.	June.	N. Loch Choin. Visited Loch Moraig but did not nest there.
21.	Diver, Red throated.	Colymbus septentrionalis.	Rare, first in 1909.	No nests seen.	Visits Loch Bhaic to feed.
22.	Dotterel.	Endromias morinellus.	Local.	June.	N. Chaorninn. Dalnaspidal. Sgairneach Mor.
23.	Dove, Ring.	Columba palumbus.	Increased since 1908.	Few nests.	Unpaired Flocks feeding May and June.
24.	Dove, Stock.	Columba œnas.	Very rare.	Rock breeding here.	N. Glen Tilt.
25.	Duck, Tufted.	Fuligula cristata.	Common.	——	N. Lochs Moraig, Fincastle, and other Lochs.
26.	Duck, Wild Mallard.	Anas boscas.	Common.	May.	N. Most Lochs and Rivers.
27.	Dunlin.	Tringa alpina.	Rare.	Early June.	N. Loch Moraig, Loch Choin, and nearly 3000 ft. up on Chaorninn.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
28.	Eagle, Golden.	Aquila chrysætus.	Rare.	——	N. Nested Glen Gurnaig, Tarf Water, Con Craig, Ben Vrachie and Craig Upley.
29.	Falcon, Peregrine.	Falco peregrinus.	Rare.	Nests—Glentilt; Rocks above Loch-an-Duan.	N. Forrest Lodge. Tarf Water.
30.	Flycatcher, Pied.	Musicapa atricupella.	New comer, 1929.	No sign of nests.	Bank of River Garry at foot of Tulach Hill.
31.	Flycatcher, Spotted.	Musicapa grisola.	Common.	May-June.	N. Tiltside. Blair Atholl.
32.	Gold Crest.	Regulus cristatus.	Common.	May.	N. Garryside. Falls of Bruar.
33.	Gold Finch.	Carduelis elegans.	Rare nester.	——	N. Black Island Wood. Bridge of Tilt. Wood End. Lude.
34.	Goose, Canadian, or Canadian Brent.	Bernicla Canadensis.	1 Pair with 6 young.	——	N. Loch-an-Duin
35.	Gooseander.	Mergus Meiganser.	Common, 1908; Fishery Board reward will make it extinct.	Choin Water (Rocks) Milton of Invervack (Tree) Bruar Water (Rock) Choin Water.	N. Young brought down Rivers in June by the Duck. Drakes flock after young are hatched.
36.	Great Crested Grebe.	Pedicips crestatus.	Visited Loch Moraig.	No nest.	——
37.	Grebe, Little.	Tachybaptes fluviatiles.	Rare.	——	N. 4 Pairs, Loch Moraig. 1 Pair, Loch-na-Leathain.
38.	Greenfinch.	Ligurinus chloris.	Common, except on hills.	——	——
39.	Greenshank.	Totanus canescens.	Very rare.	Loch Choin and the Dhu Lochan there.	N. Bare stoney ground. Burnt heather. Odd birds seen Loch Valican, Loch Garry, etc.
40.	Grouse, Black.	Tetrao tetrix.	Common.	——	N. Bruar, Wood End, Lude, etc.
41.	Grouse, Red.	Lagopus scoticus.	Common.	——	N. Not over 2000 ft.
42.	Gull, Black headed.	Larus ridibundus.	Common, Fishery Board reward.	Dhu Lochans.	N. Loch-na-Leathain. Loch Valican. Loch Moraig.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
43.	Gull, Common.	Larus canus.	Common.	——	N. Loch Choin, open moor above Invervack on Kindrochat ground, Loch Valican, and north-west of Loch Moraig.
44.	Heron.	Ardea cinerea.	Rare.	——	N. Loch Moraig, Loch Fincastle.
45.	Jackdaw.	Corvus monedula.	Common.	A rock nester here.	Falls of Bruar, Old Bridge of Tilt, Rocks above Tenandry.
46.	Jay.	Garrulus glandarius.	Numerous.	——	N. Hill Woods near Moraig, Fincastle Woods, Blair Castle policies.
47.	Kestrel.	Tinnunculus alandarius.	Infrequent.	Rock nester.	N. Choin Water, Rocks above Tenandry.
48.	Kingfisher.	Alcedo ispida.	Rare, 1 pair.	Riverbank on the Garry, opposite Blair Atholl Station.	N. Seen Black Island.
49.	Lapwing.	Venellus vulgaris.	Common.	——	Even up to hill ground.
50.	Linnet.	Linota cannabina.	——	No nest here, but possibly in Strath Tummel.	Many seen in farm yards in winter.
51.	Martin, House.	Chelidon urbica.	Common in villages with overhanging roofs.	——	N. Large colony up Glen Banvie away from building. Probably rock nesters.
52.	Martin, Sand.	Cotile reparea.	Common.	——	N. Sandy banks of most rivers.
53.	Merganser, Red breasted.	Mergus serrator.	Not seen, though reported.	——	Gooseander mistaken for it.
54.	Merlin.	Falco æsalon.	Rare.	4 Eggs.	N. Carn Liath. Chireachain Water. Loch Choin.
55.	Moorhen—Waterhen.	Gallinula chloropis.	Common.	——	N. River Garry, Black Island Wood, etc.
56.	Nightjar.	Caprinulgus europæus.	Rare, spasmodic.	2 Eggs. June.	N. Struan. Frequently seen Wood End, Blair Atholl.
57.	Owl, Barn.	Strix flammea.	——	——	Wood End.
58.	Owl, Little.	——	——	——	Seen on Loch Choin.
59.	Owl, Long eared.	Asio otus.	Not common.	——	N. Near Lude House. Black Island. Wood End.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
60.	Owl, Short eared.	Asio brachyotus.	Rare.	1 Nest. June 1910.	N. Island on Loch Choin.
61.	Owl, Tawny.	Syrnium aluco.	Common.	April. 3 eggs. Often rock nester.	Lude grounds, Black Island, Wood End, etc.
62.	Oyster Catcher.	Hæmatopus ostralegus.	Common.	Clutch, generally 3.	N. Flocks of non-nesting birds seen May-June. Gravel beds, River Garry, etc., and has extended to the high moors.
63.	Partridge.	Perdix cenerea.	——	Black Island. Lude House Drive.	N.
64.	Petrel, Storm.	Procellaria pelagica.	One.	——	Dead specimen at Loch Choin, 1913.
65.	Pheasant.	Phasianus colchicus.	Common.	——	N.
66.	Pipit, Meadow.	Anthus pratensis.	Very common.	——	N. A nest observed near summit of Cairn Liath, in rock.
67.	Pipit, Tree.	Anthus truralis.	Common, 1917-30. Cuckoo combination, common in England, once observed.	——	N. Craggan Wood. Black Island, Blair Atholl. Glen Erochy.
68.	Plover, Golden.	Charadrius pluviates.	Conservative and consistent nester.	Nests 700 to 1500 ft.	N. Path, Invervack. Loch Choin. Dhu Lochan.
69.	Plover, Ringed.	Ægialatis hiaticula.	Rare, 2 pairs. Last seen 1935.	3-4 Eggs. June.	N. Gravel bed, River Garry.
70.	Pochard.	Fuligula ferina.	Rare.	——	Pair seen on Loch Moraig in June. 8 males on Loch Moraig, June, 1934.
71.	Ptarmigan.	Lagopus mutus.	Local, 2000 feet.	6-8 Eggs.	N. Dalnaspidal. Cairn Liath. Slopes of Schiehallion.
72.	Raven.	Corvus corax.	——	Glen Tilt. Loch Choin. Schiehallion.	N. Young seen at Loch Choin.
73.	Redpoll, Lesser.	Linola rufescens.	Common, 1908, rare now.	May. 5 eggs.	N. Aldclune. Black Island. (Larch and Alder trees).

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
74.	Redshank.	Totanus calidris.	Common and increasing.	——	N. Glen Fender, Loch Moraig, Scottish Horse Camp ground, Golf Course, Blair Atholl.
75.	Redstart.	Ruticilla phœnicurus.	Common.	Wall nester.	N. Blair Atholl. Black Island.
76.	Ring Ouzel.	Turdus torquatus.	Frequent. Isolated pairs.	Glen Fender. Choin Water. Glen Tilt.	N. The Gurnaig.
77.	Robin.	Erythacus rubicula.	Common.	May-June.	N.
78.	Rook.	Corvus frugilegus.	Common and decreasing.	——	N.
79.	Sandpiper.	Tringoides hypoleucus.	Common.	River and Loch sides.	N. Loch Choin, Loch Bhaic, Loch Moraig, and Burns.
80.	Scoter, Black Duck.	Œdemia nigra.	7 Pairs.	Paired, but no nest seen.	Loch Choin. Birds leave in July.
81.	Sheldrake.	Tadorna cornuta.	1 Bird, 1922.	——	River Garry, near Golf Course.
82.	Siskin.	Chrysomitris spinus.	Frequent.	May.	N. Blair Atholl. Black Island. Wood End.
83.	Skylark.	Alauda arvensis.	Common.	Low pastures even to foothills of Ben-y-Gloe. Clutch, 4.	N.
84.	Snipe, Common.	Gallinago collestis.	Frequent.	L. Moraig, Tirene, Glen Fender, etc.	N.
85.	Sparrow, Common.	Passer domesticus.	Common.	Not on high ground.	N.
86.	Sparrow, Tree.	Passer montanus.	Rare.	Hole in tree at R. Garry.	N. Golf Course, Blair Atholl.
87.	Sparrow Hawk.	Accipiter nisus.	Few pairs.	Lude Drive, Black Island. Wood End. Near L. Moraig.	N.
88.	Starling.	Sturnus vulgaris.	In 1900 rare, now common. Decreasing 1937.	——	N.
89.	Stonechat.	Pratincola rubicola.	First in 1932, now 4 pairs.	March-April.	N. Path, Invervack to Loch Choin. Moor above Milton of Invervack.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
90.	Swallow.	Hirundo rustica.	Fairly common.	——	N. Villages. Farm buildings.
91.	Swift.	Cypselus apus.	Common and local.	——	N. Blair Atholl, etc.
92.	Teal.	Querquedula crecca.	Local.	——	N. Loch Moraig, Loch-na-Leathain. Dhu Lochan. Loch Bhaic.
93.	Tern, Common.	Sterna fluviatilis.	Rare.	4 Pairs. Nest—Gravel beds, R. Garry. Scottish Horse Camp.	N.
94.	Thrush, Missel	Turdus viscivorus.	Common.	——	N.
95.	Thrush, Common.	Turdus musicus.	Common.	——	N.
96.	Tit, Blue.	Parus cæruleus.	1908, not common, now common.	——	N. Recently pest in Blair Atholl gardens. Attack buds and pods, sweet and garden peas.
97.	Tit, Coal.	Parus buttanicus.	Common.	——	N. Walls, and sometimes in holes in the ground.
98.	Tit, Great.	Parus major.	Frequent.	——	N. Tiltside, Blair Atholl. Lude Drive. Black Island.
99.	Tit, Long tailed.	Acredula rosea.	Fairly common.	Early nester.	N. Wood End. Pass of Killiecrankie. Black Island.
100.	Tit, Crested.	——	Rare.	——	Seen at Blair Atholl, 1932.
101.	Twite.	Linota flavirostris.	First, 1908.	May. 4 eggs. One Cuckoo combination seen, Milton of Invervack.	N. Moor above Milton of Invervack.
102.	Wagtail, Pied.	Motacilla lugubris.	Common.	April-May.	N. Walls and banks.
103.	Wagtail, Grey.	Motacilla melanope.	Not common.	——	N. Garryside. Tilt Bridge. Choin Water. Fender Burn.
104.	Warbler, Garden	Sylvia portensis.	Not common, but frequent on low ground.	Shy. Dummy nests in vicinity of real nest.	N. Lude Lodge, Wood End Road, etc.
105.	Warbler, Sedge.	Acrocephalus phragmitis.	Very rare.	One nest. 5 eggs. Aldclune.	N. Arrives early. Most seem to pass on.

	Common Name.	Scientific Name.	Occurrence.	Nests.	Observed.
106.	Warbler, Wood.	Phylloscopus sibilatrix.	Common.	6 to 7 eggs.	N. Frequent areas of Beech trees, Pass of Killiecrankie to Tummel Falls. Tilt Wood, Blair Atholl.
107.	Warbler, Willow.	Phylloscopus trochilus.	Common.	—	N. Black Island, Tilt Wood, Tulach Hills, etc.
108.	Wheatear.	Saxicola œnanthe.	Fairly common.	May-June. Wall nester. Rabbit holes. Stone heaps.	N. Blair Atholl Road to Loch Moraig, Golf Course, Scottish Horse Camp, etc.
109.	Whinchat.	Pratincola ruberta.	Formerly common, but decreasing.	3 Pairs. Railway side, Blair Atholl.	N. Glen Erochy to Auchleeks.
110.	Whitethroat.	Sylvia cinerea.	Rare.	4 Pairs.	N. Aldclune, Wood End, and near Station, Blair Atholl.
111.	Wigeon.	Mareca penelope.	Rare.	Seen Loch Valican, 1905. Loch Choin.	N. Loch Bhaic, 1929.
112.	Woodcock.	Scolopax rusticula.	Common.	March-April. Double brood.	N. Black Island, Wood End Plantation, Glen Tilt, Killiecrankie, etc.
113.	Woodpecker, Great Spotted.	Dendrocopus major.	Unknown till 1914, rare now.	May. Woodend. 6-8 eggs.	N. Nesting holes harried by Starling.
114.	Wren.	Troglodytes parvulus.	Common.	Far up hill burns.	N.
115.	Wryneck.	Jynx torquilla.	One observed.	No nest.	Wood End.

Other Birds observed in various years throughout this Survey were:—

Water Rail.	Rallus aquaticus.	—	—	Dead specimen.
Common Buzzard.	Buteo vulgaris.	—	—	In winter.
Gull, Great Black Backed.	Larus marinus.	—	—	In June. River Tilt.
Gull, Lesser Black Backed.	Larus fuscus.	—	—	River Tilt.

No nests of these were found.

In June, 1914, though outside the area, a nest and eggs of Phalarope (Red necked) (Phalaropus hyperbacus) was seen at Loch Inch, and the bird was there in 1916.

XXXVII.—SOME NOTES ON THE NATURAL HISTORY OF WHALES.

By LESLIE COMRIE, B.Sc.,

University College, Dundee.

(Read 11th December, 1936.)

Though we still see on occasion the cetaceans confused with the fishes, many of the old and often far-fetched ideas are rapidly dying. The body shape and habitat are to blame very much for the errors of the past. A study of any of the fast moving aquatic animals shows a similarity in shape—all approaching the ideal for streamlining—so that apparently the habits and environment have dictated the shape. The general ancestral mammal characters remain unaffected or little modified. The body temperature remains high, air is breathed, and the young are carried in the mother before birth, at which time they are well developed and normally about one-third the mother's length. The regular coating of hair or wool is very much reduced, being usually represented by a few hairs in a patch near the mouth. The insulation against heat loss is obtained by means of a layer of fibrous fatty tissue, the blubber, which in some cases is one foot in thickness and lies immediately below the skin; this is smooth and usually black. The fore-limbs are modified as flippers, and these, which at one time may have helped in propulsion, are now only of use as stabilisers. At the same time, a dorsal fin may be present, and, though there is no skeletal basis, it may have a corresponding function to that of the one present in fishes. The rear limbs, very much reduced in size, are not externally apparent, only a few bones are present, and these are within the body. Associated with this there has been a great reduction in the pelvic girdle which has facilitated the development of large calves owing to the removal of mechanical difficulties associated with parturition. The tail flukes are horizontally arranged and have a cartilaginous and not a bony skeletal structure. When the body is examined, it will be noticed that it is vertically flattened in the tail region just in front of the horizontal flukes, the body movements are such as to give to this region a sculling motion which results in a powerful forward drive to the body as a whole—whales have towed boats against the engines for two days after being "struck." The shape of the tail is of great use in sounding, *B. mysticetus,* the Greenland whale, going down as far as one mile in a dive; where speed is concerned, porpoises are reputed to get up to 60 m.p.h. when racing a boat in a frolicsome mood.

In the skull the structure has been modified so that the nostril passages have moved back for the blowholes to open on the top of the head. In the whale-bone forms no teeth are present in the adult condition, though they are discernable in the fœtus. The neck vertebræ are much shortened and fused, the shoulder-blade is one bone, the scapula, which also includes the girdle. The vertebræ have lost their articular processes with the result that the backbone has become very much more flexible, just like a fish one.

The teeth are mostly homodont, *i.e.*, all similar and conical in shape. The blood is very plentiful and richer than normal mammal blood in hæmoglobin, the oxygen carrier; connected with the blood system there is an interesting development in that the vessels are spread out in plexuses, *i.e.*, open networks, the *rete mirabile* which act as reservoirs to store first the enriched blood and then later the depleted blood during a dive. The lungs are normal. The digestive system is typical of the regular mammal form with the stomach apparently in four chambers, arranged not unlike the chambers in the ruminants. The kidneys are large and characteristic, and are composed of a mass of small kidneys bound together. The reproductive system is of normal mammal type, the testes being internal: normally, one calf is borne and occasionally twins are met with, though up to six fœtuses have been recorded. The time the calf is carried is doubtful, but it is unlikely to be more than a year, more possibly 8—10 months. Pairing may be annual, but in some it appears to be once in two years; in some it is seasonal, but others seem to breed all the year round. There is a tendency for young animals to be caught congregating in warm waters to the south, which indicates that the females go to warmer water for parturition so that the new born young will not be chilled. This may be one of the factors affecting migration, though the latter is an obscure subject, and is also to a great extent bound up with food supply, and, in the North Atlantic, with the flow of the Gulf Stream. There is definite knowledge that the North Atlantic Right Whales come north in the late Spring and, in a cold year, linger off the coast of Scotland, but if the year is warm they hurry north to the Faroes and Iceland. They keep well out to about 10 degrees W., about 200 miles west of the Hebrides, apparently preferring the deeper channel of the stream; from October to February they may be seen near the Bay of Biscay, probably moving down with the cold weather so that by December they are at their furthest south in the region of the Azores.

The whales, though at present a very well defined group, may be from two different evolutionary lines; present opinion, however, favours an ungulate stock. The fossil Zeuglodon is certainly the half-way step in dentition to the Toothed Whales, but whether the Right Whales are from the same stock or are a case of convergent evolution is a debatable point. The second possible origin is from the Carnivora, which is quite possible taking the food habits into consideration, since they are almost all flesh eaters. In comparison with the Cetacea, the Seals and Sirenia are aquatic mammals, but these are not nearly so modified in structure. The Seal pelvis is still present, but so arranged that the rear limbs act as paddles, being arranged horizontally like the whale flukes; furthermore, these two groups come to land a great deal, a habit which only one whale exhibits strongly, the Pacific Grey Whale, which lies among the surf and at times has been hunted there. On one occasion it is reputed to have turned the tables and chased the hunters on to the land and treed them.

The whales are divided into three main groups: (1) the Archæoceti, all fossil and belonging to the Eocene times, the main representative being the widespread Zeuglodon type; (2) the Mystacoceti are the true Whalebone whales characterised by the size of the head, with an enormous mouth containing a very large tongue; teeth are absent, but in their place and hanging from the upper jaw are the whalebone or baleen fringes of which the fine bristles acting together form a very efficient sieve. Even taking into consideration the fossil reptiles, this group includes the largest of all animals; the water acting as a support to the whole body has allowed of a size impossible on land or even in the swampy homes of the reptiles. These whales grow up to a size of 100 feet and a weight of 150 tons. They live by filtering out the small animals from the planktonic soup which nature provides in the form of floating organisms in the sea. Certain of the Rorquals swim on their sides with their mouths open when feeding, and several tons of this Krill, as the food is called, form a meal. This Krill may be either in the form of Crustacea, shrimp-like organisms, or in some cases of Pteropod molluses; in the late summer, however, some of those caught to the north of Scotland have been found to have been feeding on young herring. There are two genera in this group, the Balænæ—Right Whale type—and the Balænopteridæ—the Rorqual type. Group (3) the Odontoceti—the Toothed whales. The teeth present are conical and the dentition homodont; the blowhole is single and several ribs are attached to the sternum. This group includes all the other whales such as the Dolphins, Sperm, Killer, Caaing (Pilot), etc.

In the earliest times, whaling was carried on from the shore such as in the Bay of Biscay and off the coast of Norway, and then, later, in the Greenland bays. This coming to shallow waters may have been connected with the breeding habits in the last case, and may account for the rapid decrease in the Greenland Whales, since, if these were the most favourable grounds for breeding, going elsewhere would react unfavourably on the young, and it appears that once a ground has been left the whales do not readily return. There is a record of a report to King Alfred on whales from Norway. At those times whales were harpooned for the sake of the oil, baleen was of no commercial importance. The whale of those times was the Biscay whale or, as it is also known, the N. Atlantic Right Whale or Nordkaper, its proper name has been changed from the old one of *Balæna biscayensis* to *B. glacialis*. In connection with the names there is some disagreement over whether the apparently similar whales from the southern hemispheres should be given the same name as those met to the north of the equator. The Southern Right Whale is a case in point, since it is very often known as *B. australis*. As whalers worked their way further north, they made contact with the Greenland Whale and hunted it with six men in a boat, hand harpoons, and six hundred fathoms of rope;

which was a very perilous business indeed. The habit of coming to the shallow bays rendered them easy prey from land stations, and each country claimed for its men a stretch of the coast. The whales soon became wary or frightened, and took more and more to the ice. The knowledge that the whalers got of the migrations helped them in their later visits. The young whales and cows went north first, and were later followed by the larger males and some of the females. As the grounds became depleted, the whaling moved from Spitzbergen and Greenland round to the Davis Straits and also up into the Behring Sea, until finally, after about 1850, the grounds were fished out for the scale to which the industry had grown. In 1865 a new step was taken by the introduction of the whaling gun to fire the harpoon : this allowed them to tackle the faster and more mettlesome Rorquals. In this group, *Balænoptera musculus,* the Finner was the main source of profit; it is 60-70 feet long, and is the one which swims on its side while feeding; of these 2,400 were taken by the Scottish fleet off Orkney and Shetland, 1908-1914; *B. sibbaldi,* the Blue Whale of our fishing and the Sulphur Bottom of the American catches is the largest whale, reaching to 80-85 feet in length. American harpoons have been taken from whales in British waters, and one of these whales once pulled a boat against the screw for 122 miles in 26 hours after being struck. They are commoner near Iceland and near the ice; the best catches were from June to August, and in 1908-14, 109 of them were taken. Latterly, *B. borealis,* the Sei Whale, came into prominence, though only 40-50 feet; in 1908-14, 1,300 of these were taken. *Megaptera nodosa,* the Humpback Whale, only contributed 31, and of these the main number (23) were males. This whale is unfortunate in being the first victim in a new field which is being opened up, though it soon fades out of the picture either from timidity or lack of numbers. In the old days it was not troubled very much because of the poor oil yield and the fact that it sank and was lost when dead. Of the Toothed Whales, *Physeter catodon,* the Sperm Whale, of which large males only are caught in the north—42 during the years 1908-14—was the most sought after. In the peak year, 1837, the American fleet took 5,329,138 gallons of oil—it was in 1857 that petroleum came as a serious competitor. This 60 foot whale has an enormous head and in it a " case " holding 500 gallons of spermaceti and oil : occasionally in the gut is found a morbid concretion—ambergris—which has no smell of its own but is a very fine holder of scent. Of the smaller toothed forms, the Pilot Whale, *Globiocephalus melæna,* used to be of importance to Orkney and Shetland, where the dried meat was fed to cattle. The whales when sighted near land were driven into shallow bays and trapped by being stranded. There is a record of a Biscay Whale which tried to rescue its calf by taking it under a flipper after the calf had been harpooned. the rope broke, but the calf died. In olden times, Porpoises, *Phocæna communis,* which favour estuaries (I have seen them myself several times as far up as the Tay Bridge), were hunted in the Seine even at Paris for the sake of their flesh which would pass as fish on Fridays.

The introduction of gas lighting in 1815, and the use of petroleum for illumination after about 1850, both helped to reduce the growing demand for whale oils for lighting purposes, and so indirectly lessened the attacks on the rapidly falling population of these animals. The oil is still of use in commercial processes, however, and the whale-bone, though it has lost much of its importance in dressmaking and as a stiffener in silk manufacture, is still used for wigs, bristles, etc. Recently, an unexpected use has arisen, for it was found that the ovaries are a very good source of hormones for use in medicine. Modern whaling is now mainly followed from shore bases at S. Georgia and in the Antarctic Seas. A new system of the use of floating factories, where the whales are " tried out " and the flesh ground up on board, has been developed.

The more recent knowledge of whales around Britain is from the records of strandings on the shore or of bodies cast up. The British Museum has made careful records of these since 1913, and a striking feature of these is the greater number of strandings on the East coast. For this there are two possible reasons, the first being that the shores there are flatter and more likely to trap unwary whales than the steeper western shores; the second being that the eastern side is much more densely populated and the bodies are more likely to be seen and recorded. These factors, however, are not by any means the whole story of the apparent causes of the accidents.

There is one species of Toothed Whale whose behaviour does not fall in with any one explanation; in fact, its whole existence is a puzzle, and its name, the False Killer, *Pseudorca crassidens*, is in keeping with its appearance. The first record of it was from a subfossil skull dug up in the Fen district in 1843, and described by Sir Richard Owen. To everyone's surprise, this supposedly extinct animal appeared to the number of about 100 in Kiel harbour in 1861, and from the remains of several which were later found, J. Reinhardt wrote a fuller description of the species. Since then, from the various strandings it has been shown that this animal is world-wide in its distribution. These periodic visitations may vary from one or two up to several hundreds, *e.g.*, Chatham Island in 1906, several hundreds; Dornoch Firth in 1927, about 150; near Cape Town, over 100 in 1928; at Velanai Island in 1933 there were 167; and 21 at Glamorgan in 1934, so that they exhibit no special choice of locality. In September, 1935, one came ashore on the Portuguese coast; this was the first of a series which started on the 16th November at Donna Nook in Lincolnshire and finished with the last at Port Edgar on the Forth on the 12th December, leaving a total of 75 scattered up the East coast.

To find an explanation for this is not easy, except that they may have come in with an influx of Atlantic water, and in trying to make their way out of the North Sea, found it barred by land, and in trying to nose a way round been trapped on shallow shores. They are by nature deep water forms, and this fact gives another possible explanation which would also cover a suicidal rush ashore by a school in South Africa about the same time. In that case there had been a storm for three days and the sea floor had been stirred up, making the water turbid. A similar state of affairs would hold in the North Sea, which is not so clear as the Atlantic. The unfamiliar conditions might upset the school and the grit interfere with their eyes, and thus drive them into behaving abnormally. From strandings in Holland there appear to have been large numbers of them in the North Sea at that time, and that they tended to sweep round with the stream of the Atlantic inflow.

The largest number of the 1935 stranding were stranded on the sands at Buddon Ness on 26th November, 1935, on a flat shore. Since they were under 25 feet in length, they were not Fish Royal, so that the disposal of the bodies fell to the duties of either the County or Health Authorities. On the 29th, after obtaining the permission of the Medical Officer of Health, and arranging that the bodies should be allowed to be examined before burial, a party from University College, Dundee, under Professor Peacock of the Zoology Dept., and Professor Garry of the Physiology Dept., went down and made as complete an investigation as possible under the circumstances. A complete series of body measurements was made, where possible, and from this, knowing the sex of every specimen, an attempt was made to discover if there was any sex dimorphism. Beyond the fact shown by plotting the numbers of each size on a graph, that the adult males seem to be up to 3 feet longer than females, nothing characteristic was noted, though in the actual specimens there appeared to be a tendency for the pad of fat on the snout in the male to be larger and to grow more quickly than in the female. Sexing thus depends entirely on examining the genitalia. Among the females, two were carrying calves, and were 14 feet long, so that maturity is before this size is reached. The largest male was 19 feet, and female 15 feet 6 inches, with means of about 17 feet 6 inches for males, and 14 feet 6 inches for females. The fœtuses were 3 feet 7 inches and 3 feet 10 inches; these appeared to be about full time, the membranes of one being easily detached from the mother, though this character is not dependable and a 6 feet fœtus has been recorded.

The eyes are small and near the angle of the mouth, no external ears are seen, the nostril is a single median aperture in the middle of the snout, and opens into a chamber which acts as a water-lock during a dive. The teeth are conical, and by means of counts of the teeth we came to the conclusion that they have a homodont dentition of 8/9; this was confirmed by an X-ray of the fœtus showing a similar number. The tongue is large and mobile, while at the back of the inner nostril is a tube-like prolongation to the trachea to enable the animal to breathe and yet open its mouth under water without getting water into the air passages. The skin is black and shiny, with occasional stellate marks like old scars showing white on it. Round the mouth were some circular marks, $\frac{3}{4}$ inch across, which we took to be cuttle fish sucker marks, and this was confirmed later when the stomachs were opened and the beaks found there. There was no sign of hair on the adults, but the fœtuses show five hairs on either side of the upper lip. The flippers are of little apparent use for swimming, though they would act well as stabilisers and to regulate the angle of dive and also in turning. The dorsal fin is stiff and would help in maintaining stability; the flukes are equal and with the flattening of the rear of the body vertically just in front of them form a powerful propelling organ.

The male genital opening is nearly twice as far from the anus as the female aperture. The penis is about 3 feet long, and is normally retracted into the body. The testes are about a foot long and internal, *i.e.,* in the abdominal cavity. The female organs are very small in the immature stage, but increase greatly in size during gestation. The ovaries are about 10 cm. long, and on them can be seen the characteristic *corpora lutea* which are like button mushrooms; in pregnancy they become very large, about one-and-a-half inches in diameter, with a very corrugated surface. The ovarian funnel is unusually well developed. The kidneys are of the usual type, being composed of masses of smaller ones all bound together and forming a fairly large organ about 9 inches long in a 9 feet 4 inches animal.

In the abdomen, the stomach appears to be in four chambers, one of which in some cases contained masses of fish bones and, mixed with them, cuttle-fish beaks, otoliths, etc. The rest of the gut is normal mammal type, but is of interest because of the very strongly developed lymphatic vessels which show the valves lying in the mesentery very well.

The brain, which is more than twice the size of an adult human brain, has a well convoluted surface, and is rather a surprise when one considers the position in the classification of the mammals that these animals are placed. The actual internal structure of the brain has not been investigated, so that nothing definite as regards intelligence can be suggested, though the size does give some grounds for speculation.

The fœtuses were miniatures of the adults, so that there is little to remark on in connection with them descriptively. The interest here lies in the fact that, while fresh, they were injected, so that the blood systems might be dissected. On X-raying one, it was found that the vermilion had caused a shadow of this system to be thrown on the plates, so that not only is there a fine picture of the bones, but, in relation with them, the small vessels supplying the blood. The main aim in the photographs was the dental formula of the non-erupted teeth in the gums; this was extremely successful, and, as stated, confirmed our idea as to the figures of 8/9. There was one unexpected detail shown up, and that was the outline of the spinal cord; this can be explained on the grounds that the *rete mirabile* surrounds the nervous system and the presence of quantities of injecting fluid in the vessels of this structure would give a shadow. Another point that has become evident on opening one is the presence of remains of the vestigial pelvic girdle in the body wall; this was also shown in one of the larger specimens, though as yet the shape and details have not been investigated. The details of ossification of the centre of the vertebræ are very clear, and show the canal arrangement of this process.

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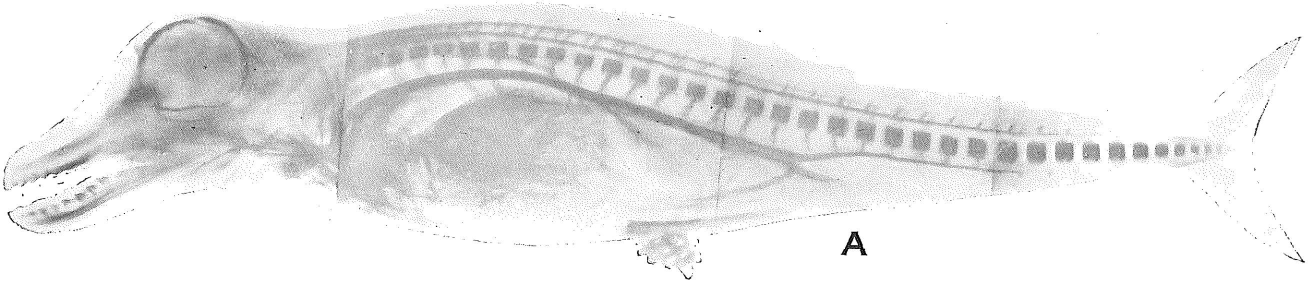
NOTES DESCRIPTIVE OF PLATE XXXVIII.

(*Upper.*)—X-Ray photograph of female fœtus of *Pseudorca crassidens*, False Killer Whale, 3 ft. 10 ins. (F.35), lateral view, injected with starch and vermilion, taken at 6 feet.

Of the skeleton, skull bones shown well with shadows of the calcium salts in the teeth which have not yet erupted Ribs shown and the start of neural spines—Centra of vertebræ showing fine canals in developing bone—two centres to each centrum. Remains of pelvic girdle—faint shadow at A. Lungs show as clear space in thorax. Liver very solid owing to presence of blood vessels. Dorsal aorta shows well with cœliac vessel in abdomen and umbilical vessel to rear. The hæmal arches show up well (paired vessels), and running parallel, shadow-like veins. Neural canal shows up very clearly, probably by laking of injection in *rete mirabile,* associated with nerve cord.

(*Lower.*)—Reproduced by courtesy of *The Dundee Courier and Advertiser.* False Killer Whale (*Pseudorca crassidens Owen*); young female, 9 ft. 4 ins., stranded near Carnoustie, November, 1935.



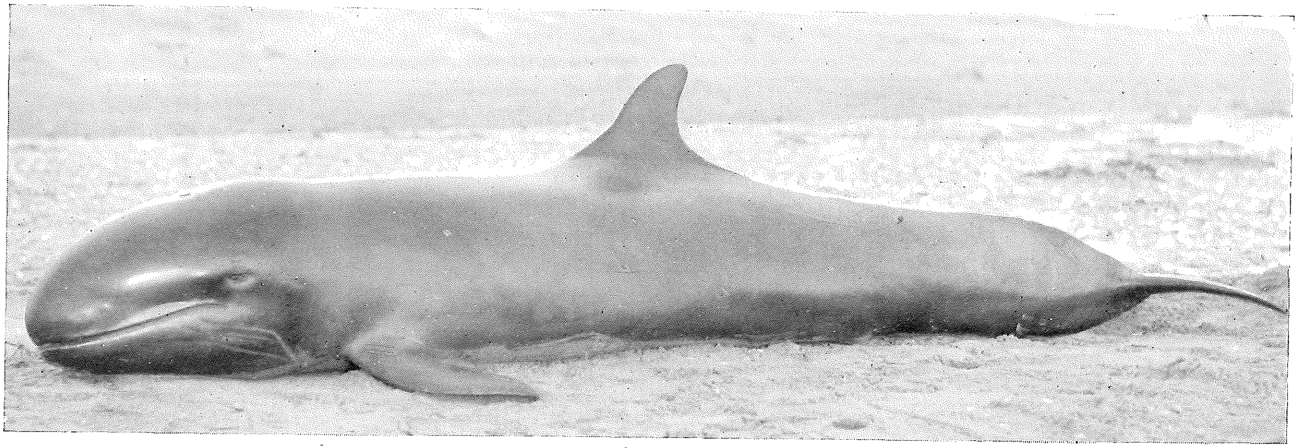


Plate XXXVI.

Descriptive Notes—see Page 189.

XXXVIII.—NOTE ON RECENT TEMPORARY ROCK EXPOSURES WITHIN THE CITY OF DUNDEE.

By C. F. DAVIDSON.

(Read 8th January, 1937.)

The igneous geology of the city of Dundee and its environs forms the subject of two papers communicated by J. W. Harris (1932) to the Edinburgh Geological Society in 1925 and 1926. Recent temporary rock exposures additional to those described by Harris have been noted by the writer in the last few years, and as they somewhat extend our knowledge of the geology of the city and necessitate alterations on Harris's map, they are here put on record.

Castle Street.—During the laying of an electricity cable in 1932, medium-grained dolerites were exposed close to the surface throughout the length of Castle Street. Little variation was seen in these rocks in the hand specimens, and schlieren or segregations were not evident. It was possible, however, to distinguish between a brownish-red hæmatitised modification and the normal bluish-grey dolerite.

Under the microscope these rocks are seen to be non-ophitic quartz-hypersthene-dolerites similar to those of Balgay and of other localities throughout South Angus and the adjacent part of Perthshire (*vide* Balsillie, 1934). They are considerably decomposed, the bluish-grey type in particular being extensively calcitised, albitised, and chloritised. The hæmatite-stained specimens, which are distinctly fresher than the others, exhibit a well-developed devitrified mesostasis, and are concomitantly the poorer in free quartz.

West Port.—Exposures of a uniform bluish-black dolerite were observed during excavations in 1933. The rock, like that of Castle Street, is a quartz-hypersthene-dolerite similar to that of Balgay.

Wilkie's Lane.—Another exposure of quartz-hypersthene-dolerite occurred in excavations for building in 1933 at the top of Wilkie's Lane. Here again, throughout a freshly-cut cliff ten feet high, the rock was seen to be quite uniform. The major joints dip in an easterly direction at appromimately 70°.

Victoria Road.—During 1932, a particularly interesting series of exposures was laid open in excavations for an electricity cable along the western part of Victoria Road. My attention was drawn to these by Mr. Alex. Christie, formerly of University College, Dundee. The rocks were commonly in a very decomposed condition, but from the occurrence of slaggy and amygdaloidal horizons they are believed to be lava flows. One of the freshest specimens, from the west end of the cutting close to the Wellgate, was sectioned, and is seen to be a rather decomposed augite-andesite, in which the ferromagnesian is confined to the base of the rock. The feldspar laths, of the composition of acid labradorite, are diversely oriented, and a few tabular honeycombed phenocrysts of the same mineral are visible. No lavas have previously been recorded from this horizon.

Bell Street.—During an excavation for an underground petrol tank at the Dundee City Transport Department's depot at Bell Street in 1934, rock was encountered close to the surface and had to be quarried by blasting. The moderately fine-grained rock here discovered is a very fresh non-porphyritic ophitic olivine-tholeiite, in which many of the olivine crystals are undecomposed or but little serpentinised. This petrographic type has not hitherto been found within the city, but the rock is exactly similar to that from the quarry at Newton Farm, Auchterhouse, recently described by Balsillie (1934, p. 139) in considerable detail.

South Union Street.—In January, 1937, the writer observed some unrecorded exposures in a trench for an electricity cable in South Union Street, midway between the entrances to the West and Tay Bridge stations. A fresh, purplish-red rock, non-porphyritic in the hand specimen, occurs here within three feet of the road surface. In thin section this is seen to be a very fine-grained quartz-andesite, poor in ferromagnesians. Scarce pseudomorphs of hæmatite after rhombic pyroxene are visible, and a few small irregular masses of quartz, 0.05 mm. diameter, are present, but the bulk of the rock is formed of tiny laths and tables of andesine feldspar (maximum length, 0.2 mm.) inset in a base of very minute feldspars and iron ores.

There is no evidence to indicate whether this rock forms a flow or whether it is connected with the closely adjacent quartz-hypersthene-dolerite of Castle Street. It is, however, decidedly more acid than the rocks of the latter exposure.

Microscope sections of the above rocks have been preserved in the collections of the Geological Survey and Museum, London (numbers S. 31985—89, S. 32080), where they are available for future reference.

The writer wishes to emphasise that it is only by the recording of temporary exposures similar to those described, and by the preservation of specimens and of notes of borings, etc., that the geology of Dundee—or of any other built-up area—can be deciphered with any accuracy. The greater part of Dundee is built upon a number of igneous intrusions believed to be of Lower Old Red Sandstone age, which have only been studied in detail at Balgay, Craigie, the Law, and other areas on the outskirts of the city. The age relations of these various masses, and how far they extend under the town, is still a matter for some conjecture; but the continued publication of notices of transient outcrops (which might well be done in co-operation with the local Department of Works) would be an important step towards the preparation of a large-scale geological map of the city. Such a map would be of considerable use to public and private bodies interested in the nature of the rocks they were likely to encounter in borings and excavations.

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XXXIX.—NOTE ON THE OCCURRENCE OF GARNET SANDS IN THE TAY ESTUARY.

By C. F. DAVIDSON.

(Read 8th January, 1937.)

INTRODUCTION.

Along the coast of the Firth of Tay from Monifieth to the Buddon Ness lighthouse there may be seen, situated about high-water mark, deposits of a reddish sand differing markedly in colour from the ordinary golden-yellow sands of the beach and dunes. These sands were first investigated mineralogically by the author early in 1932, and were found to consist of garnet and other heavy minerals, but no description was then published. The following brief account is based upon notes taken at that time and on a number of subsequent visits to the area, and is prompted by the possibility that the deposits may be of some economic value. There does not appear to be any other reference to these sands in geological literature.

FIELD DESCRIPTION.

The common yellow sands of the Tay estuary in the Buddon Ness and Tentsmuir regions are formed principally of quartz grains, with frequent fragments of shell debris. A considerable number of other minerals are also present in small amount, among these garnet and iron ores being dominant.

If we examine the reddish sands, however, we find that they are very poor in quartz, and that they are composed almost entirely of grains of garnet and of iron ore—that is, of the commoner of those minerals of high specific gravity which occur in the ordinary sands. It is obvious that these heavy minerals have been concentrated from the ordinary sands by the removal of quartz and other grains of relatively low density, and that this phenomenon is principally due to water action. Each wave of the sea, as it retreats from the shore, bears with it a burden of sand particles;

but the heavier grains sink near the tide line, while the lighter are carried away seawards. In time a considerable concentration of the heavy minerals is thus formed, particularly near high-water mark where the supply of loose unconsolidated sand is greatest. Garnet sands are never found in noteworthy amount far away from the shore, and it is to the action of high spring tides close to the banks of dune sand that we must look for their origin.

Along the Monifieth shore these heavy mineral sands are well developed in many places, particularly between the months of September and April; and the writer has seen a belt several feet in width and averaging about three inches in thickness extending from the shore south of Monifieth eastwards to the Buddon Burn, and then, with a break just east of the burn, south-eastwards along the beach for a mile or more. But such large developments are exceptional, and the sands are most commonly seen in small sheltered parts of the beach. Locally the beds may at times reach two feet in thickness, and in a normal year it should not be difficult to collect at least a hundred tons of the material. There are times, however, when the sands are poorly developed, depending apparently upon the currents, tides, and other more or less fortuitous circumstances, while in stormy weather the deposits tend to be overlain by the lighter wind-blown dune sands.

MINERALOGY.

As is to be expected, all gradations in mineralogy are seen, ranging from the normal beach sands to the heavy mineral concentrates. Most of the latter, however, consist of over 85 per cent.* of minerals heavier than bromoform (specific gravity 2.88), while an average concentrate, present in bulk and collected without particular care, gave on separation a heavy mineral content of 93.4 per cent.* An analysis of several thousand grains showed another typical sample to consist of the following :—

Garnet, - - - - - -	73% †
Magnetite, Ilmenite, and other iron ores, -	16%
Quartz, - - - - - -	8%
Other minerals, - - - - -	3%

Among the " other minerals " have been noted, in approximate order of abundance : hypersthene, apatite, rutile, zircon, orthoclase, monazite, tourmaline, microcline, muscovite, chlorite, kyanite, plagioclase, biotite, augite, hornblende, epidote, zoisite, anatase, staurolite, and (?) orthite. Calcite and aragonite (shell debris) are always present in varying amount. A number of other species of detrital minerals are undoubtedly present, but no detailed examination has been made for this note.

A typical normal sand from the tidal reaches at Buddon was separated by bromoform, and showed a content of 20.8 per cent.* heavy minerals. It is noteworthy that the heavy fraction of this

*Weight percentage. †Numerical percentage.

normal sand differs appreciably in petrography from the natural heavy residues, especially in being much richer in those fibrous and flaky minerals which are probably largely removed from the natural concentrates by wave action. Muscovite is here relatively common, while biotite and hypersthene are decidedly more abundant than in the heavy sands of the beaches.

An interesting feature is the frequent association with the garnet sands of small pellets of lead, the spent ammunition of the neighbouring rifle ranges. Another artificial mineral present is carborundum, one grain of which has been observed.

Other Heavy Mineral Sands.

The garnet in the Tay estuary sands is clearly derived from the garnet-mica-schist belt of the Highlands, and accordingly one would expect the occurrence of similar heavy mineral deposits along the sandy shores where several other Highland rivers reach the sea; but nowhere does there appear to be such an extensive development as in the Buddon Ness area.

The natural heavy concentrates of the sands in the neighbourhood of St. Cyrus, to the north of the North Esk, have been worked as abrasives at intervals since the war years. Frequently these sands are characterised by a very large content of magnetite and other iron ores. South of St. Cyrus, in the Montrose-Lunan Bay districts, the writer has never observed heavy mineral sands in any large amount, while at the Arbroath south beach and at Carnoustie the concentrations are seldom more than thin streaks or lenses. On the Tentsmuir beaches to the south of the Tay, however, particularly just about two miles east of Tayport, garnet sands occur in fair quantity. Other parts of the Scottish coast have not been examined.

The mineralogy of the garnet-bearing sands of the Northumberland coast has been described in detail by Hawkes and Smythe*; but although samples rich in garnet may readily be obtained at Budle and elsewhere, these deposits do not appear to be of any economic importance.

*L. Hawkes and J. A. Smythe. *Geol. Mag.*, LXVIII, 345-61, 1931.

Economic Uses.

The principal use of garnet, exclusive of pure transparent stones employed in jewellery, is in the abrasive industry. Apart from very small quantities exported sporadically from Spain, Madagascar, Sweden, and India, commercial abrasive garnet deposits are largely confined to the American continent. Imports of abrasive garnet into Britain are not extensive, for in this country it is commonly replaced by powdered flint which has the advantage of being much cheaper, and the total British consumption of garnet until recently did not exceed 2,000 tons annually. At present the trade appears to be expanding.

Garnet sands are not as a rule satisfactory for abrasive work, since the grains are commonly rounded by mutual attrition due to wave or wind action. It is possible, however, that the deposits under consideration might be used with advantage in sand-blasting or grinding glass or similar material.

If extensive enough supplies were available, a further use might be found in the plate glass industry. Very fine garnet dusts of −300 mesh, not necessarily of great purity, are now being used extensively in the United States in the intermediate stages of the surfacing of plate glass. The local garnet sands could readily be crushed to a state of sufficient fineness for this purpose, and the presence of considerable quartz in those sands where garnet is not in very high concentration would not appear to be disadvantageous in this use.

XL.—SOME BOTANICAL NOTES FROM GLEN LYON.

By MURRAY LUNAN, B.Sc.

(Read 8th January, 1937.)

ABSTRACT.

In June of last year, the University of St. Andrews Biological Society organised an expedition to Glen Lyon, in Perthshire.

During the week in Glen Lyon we made excursions to Ben Lawers, Loch Lyon, the Black Wood of Rannoch. We were indebted to the Perthshire Education Committee for the use of the schoolroom at Invervar as a laboratory and common-room.

The object of the expedition, from a Botanical standpoint, was the study of a habitat as different as possible from that of the St. Andrews district, which we already knew. For this purpose Glen Lyon was ideal. St. Andrews is lowland, maritime, and is largely agricultural and modified by man; Glen Lyon is highland, as far from the sea as is possible in Scotland, and it consists mainly of mountain and moorland country, with very little agriculture.

Besides this, there is in Ben Lawers and its neighbours the finest station for Alpine plants in Great Britain. On Ben Lawers itself are found the Drooping Saxifrage (*Saxifraga cernua*), and a variety of Whitlow grass (*Draba inflata*), found nowhere else in Britain. High up on the west face of the mountain there is a small, rather commonplace looking scree-corrie which is known the world over for its rare Alpines, a beautiful blue Forget-me-not (*Myosotis alpestris*), an Alpine Gentian (*Gentiana nivalis*), and the *Saxifraga cernua*. Unfortunately, these are becoming increasingly rare, as they are much sought after by plant hunters, and there is a grave danger that they may soon be exterminated completely.

We made a special study of the Alpine flowers of Ben Lawers and the other mountains of the district, paying particular attention to the peculiar characteristics which enable them to survive in such unfavourable conditions. It was interesting to note the marked similarities in structure and general habit of these Alpine

xerophytes to the xerophytes of the sea-shore. Different types of plant adapt themselves in similar ways to similar environmental conditions. Of particular interest were the Dwarf Willows. *Salix herbacea* is often less than half-an-inch in height, illustrating the prevailing small size of the Alpines. Other characteristics of these mountain plants are their cushion-like or their trailing habit, the relatively large roots, and xerophytic modifications of the leaves, such as succulence or a hairy covering. These are all adaptations to the severe conditions under which they live—the strong winds, the extremes of temperature, and often lack of soil.

A special adaptation of these Alpine plants to get round the difficulty of seed formation is the adoption of viviparity, *i.e.,* in place of flowers are developed little vegetative buds which drop off to form new plants. This phenomenon we saw on the Alpine Persicaria (*Polygonum viviparum*), and the viviparous Sheep's Fescue (*Festuca ovina vivipara*).

Considering the severe conditions, it is surprising to find, high up on these mountains, delicate little plants which one associates with shady woods and sheltered meadows. Above 3,000 feet on Ben Lawers we discovered the Moschatel (*Adoxa Moschatellina*), and Wood Sorrel (*Oxalis acetosella*).

Near the summit of Ben Lawers we found Sea Thrift and Scurvy Grass which were, of course, familiar to us. These flowers are found on the seashore and on the summits of the mountains, and nowhere in between. The usual theory is that they have been forced to live in these unfavourable habitats by more strongly growing rivals.

In the short time at our disposal, we made no particular study of the Algæ and Mosses of the district, but it is worth while noting that *Nitella opaca* was found in Loch Ghiorra, an unrecorded station for this Alga.

Among flowering plants, several comparatively rare species were identified, perhaps the most interesting being *Thalictrum Babingtonii* (regarded by some authors as a sub-species of *Thalictrum minus*), found growing on a cliff-face over the River Lyon. The identification was confirmed by Mr. Evans of the Royal Botanic Garden in Edinburgh, and I made sure it was not a garden escape by writing to the gardener at Meggernie Castle. This, as far as I can find out, is the first record of the species in Perthshire.

Among Fungi, at least three rarities were discovered. One, *Cæoma Saxifragarum* growing on *Saxifraga hypnoides var. platypetala,* has been recorded only twice before in Scotland.

It was interesting to note the similarities and differences between the floras of the two habitats. There was, of course, much in common—the ubiquitous species, for example, Daisy, and the Smooth Meadow Grass, and the common weeds of cultivation like Corn-spurrey or White Dead-nettle. The peculiar species were found to be mostly in the Alpine and acid moorland flora of the Glen Lyon district, and the seashore flora of St. Andrews.

Fungi which we found in the Glen Lyon district.

FUNGI.

Hieracium Pilosella—Uredospores of Puccinia Hieracii.
Taraxacum spectabile—Aecidia of Puccinia sylvatica.
Viola canina (2 vars.)—Aecidia of Puccinia Violæ.
Viola tricolour—Aecidia and uredospores of Puccinia Violæ.
Potentilla sterilis—Uredospores of Phragmidium Fragariastri.
Galium saxatile—Teleutospores of Puccinia Valantiæ.
Alchemilla vulgaris—Uredospores of Uromyces Alchemillæ.
Anemone nemorosa—Teleutospores of Puccinia fusca.
*Saxifraga hypnoides var. platypetala—Cæoma Saxifragarum.
Urtica dioica—Aecidia of Puccinia Caricis.
*Rumex acetosa—Aecidia of Uromyces Acetosæ.
*Pedicularis palustris—Aecidia of Puccinia paludosa.
Caltha palustris—Aecidia of Puccinia Calthæ.
Ribes Grossularia—Aecidia of Puccinia Pringsheimiana.
Holcus mollis—Uredospores of Puccinia holcina.
Salix caprea—Uredospores of Melampsora sp. (prob. Larici-Caprearum).
Rosa canina—Aecidia of Phragmidium disciflorum.
Crepis paludosa—Aecidia of Puccinia major.
Mitrula paludosa on dead twigs and leaves.
Polyporus betulinus on Birch.
Fomes fomentarius on Birch.
Dasyscypha calycina on Larch (Larch canker).
Phyllachora juncea on Juncus communis.

* Rare.

XLI.—AMATEUR ASTRONOMY.

By Cyril Walmesley, A.M.Inst.C.E., M.Inst.W.E.

(Read 19th March, 1937.)

I wish to talk to you this evening about star-gazing from the point of view of the amateur, therefore I intend to describe nothing which cannot be seen, and that I have not myself seen, with a three-inch telescope—the size most commonly used by amateurs.

The first essential for all branches of observational astronomy is a knowledge of the constellations and of the names of the brighter stars. A small star atlas is required for this purpose, and a "Planisphere" is a most useful accessory. We must learn to visualise the Earth as a globe surrounded on all sides by apparently illimitable space, throughout which are scattered myriads of stars. And as this globe turns round on its axis once in 24 hours, so the observer from hour to hour finds himself facing a different vista of that space and its starry population.

Thus we see constellation by constellation rise from the eastern horizon, move majestically upwards to the meridian, and then descend to vanish below the western horizon. Some rise in the north-east, pass overhead, and set in the north-west; others rising due east, cross the meridian at an altitude (at Perth) of about 33°, and set due west; while others rise in the south-east and set in the south-west, rising but a little way above the horizon as they cross the meridian.

But the observer will soon note that the stars in the northern area of the sky neither rise nor set, but appear to revolve around the Pole star in circles of different diameters, some just grazing the northern horizon at the lowest point of their circuit, and crossing the meridian, in our latitude, some 23° to the south of the zenith, while others nearer the Pole describe quite small circles. The Pole star itself is not situated actually at the Pole, but describes a small circle around it at a radius of approximately twice the apparent diameter of the moon.

These stars which never set are known as *Circumpolars.*

To an observer at either of the Earth's poles, the pole of the heavens—which is, of course, the point to which the Earth's axis is directed—would be directly overhead, and *all* stars would be circumpolar, their apparent diurnal paths being parallel with the horizon. Such an observer would only see one half of the heavens, the other half being for ever below the horizon.

At the Earth's equator, on the other hand, the poles would lie at the north and south points of the horizon, and all the stars would appear to rise to the east and set to the west of these points, so that in the course of 24 hours, all points of the heavens would come into view.

Not only do the stars change their apparent positions in the sky from hour to hour, though, of course, never varying in their positions relative to one another, but a very few days' attention will show that, day by day, at any given hour, each star is a little to the west of its previous day's position. In fact, every star crosses the meridian nearly 4 minutes earlier each day, coming back to its original position at the end of a year.

This, of course, is due to the Earth's revolution round the Sun, which causes the background of space against which we see that luminary to shift from day to day, so that the Sun appears to trace out a path round the circle of the heavens in a year. This apparent path of the Sun is known as the *ecliptic,* and a knowledge of its position in the heavens is necessary to an understanding of what one might call the topography of the sky, for within a fairly narrow belt on either side of this ecliptic, the Moon and all the planets of the Solar System move.

Not only, then, do we see different constellations in any given part of the sky at different hours of the same night, but they also differ at different seasons of the year. For example, at this moment (March 9th, 8 p.m.), the constellations Lynx, Gemini, Cancer, and Canis Minor are on, or near, the meridian, and the Great Bear is in the north-east. Six hours hence, these constellations will be low in the west (except Lynx, which is circumpolar), and the Great Bear will be high up and to the west of the meridian.

Six months from now, these same constellations will be near the meridian at 8 o'clock in the morning, and at 8 o'clock in the evening (G.M.T.), Cepheus, Cygnus, Aquarius, and others will have taken their place, while the Great Bear will be low in the north-west.

The constellations through which the Sun's apparent path passes are known as the "Constellations of the Zodiac." The *Constellations* of the Zodiac are not quite identical with the *Signs* of the Zodiac, because, owing to a certain slow movement of the Earth's axis, the seasons are slowly advancing, and to-day the *Sign* of Aries, which the Sun enters at the spring equinox, is actually in the *Constellation* of Pisces. This movement, known as the precession of the equinoxes, completes its cycle once in 25,800 years, during which time the *Sign* of Aries will have passed in turn through all the *Constellations* of the Zodiac.

As the name Zodiac implies, the constellations of which it is composed are all supposed to represent various animals, and it is believed that they were named about 5,000 years ago. The names and mythology of the stars and constellations form an interesting study in themselves, but are outwith our present subject.

One of the first things we notice about the stars is their great diversity of brightness. Some, like Sirius or Vega, flash like fiery gems, while others can barely be detected by the unaided eye.

The old astronomers divided the lucid stars into six groups of brightness, which they called "magnitudes," the brightest being classed as first magnitude and the faintest visible to good eyesight being called sixth magnitude. This nomenclature is in use at the present day. An average first magnitude star is 100 times as bright as one of the sixth magnitude.

Besides differing in brightness, the stars also differ in colour. Some, such as Sirius or Vega, are bluish-white; others, like Capella, are yellowish, whilst some, such as Antares, Betelgeuse, Aldebaran or Arcturus, are orange or red. Among the fainter stars which the telescope reveals, we find some which are greenish or blue, and some of the double stars, to which I shall refer presently, have components of vividly contrasted colours, such as orange and blue.

How many stars can we see with the unaided eye? One sometimes hears the remark, "How bright the stars are to-night, and what millions of them there are!" Well, as a matter of fact, if on some clear night you set to work to count the number of individual stars you could see without optical aid, you would probably be rather astonished at finding that they did not number more than two or three thousand, according to the keenness of your eyesight. With an opera-glass, this number would be doubled or trebled, while with a 3-inch telescope, the number would be increased one hundredfold. So, you see, it is not such a formidable task as it sounds to become familiar with all the brighter stars.

On a clear night, we notice, in addition to the individual points of light which bespangle the heavens, a luminous arch stretched athwart the sky. This is the Milky Way. This luminous arch is composed of myriads of stars too faint to be seen individually by the unaided eye, but whose combined lustre produces a haze of light.

The Way is irregular in outline, dividing into two streams in places, branching and ramifying in others, and for the study of it I would commend a deck-chair and a pair of field glasses.

To the amateur who possesses no optical aid, but who wishes to do serious work, one of the best fields for research is offered by the observation of *Meteors*. For this work, the naked eye is supreme.

Meteors are fragments—possibly of celestial explosions—and range in size from a grain of sand to a large boulder. Untold millions of these revolve, some singly, others in huge clouds or swarms, around the Sun. Their orbits are very elongated ellipses. When, in the course of their wanderings, these particles pass near to the Earth, the force of gravity pulls them out of their orbits, and travelling with high velocities, they encounter the resistance of our atmosphere. The heat generated by the impact is so great that they are reduced to incandescent vapour, and in a few seconds are burnt away. It is this burning up which we witness when we see a "shooting star."

Occasionally, one of these bodies, owing to its size or relatively slower motion, is not entirely burnt away before it strikes the Earth's surface. As an example of this we have the Perthshire Meteorite of 3rd December, 1917, four fragments of which fell over the Sidlaws—at Carsie, Essendy, Corston, and Keithick—the latter fragment piercing the roof of Keithick Lodge. Casts of these fragments are to be seen in the Museum.

Hundreds of these bodies meet the Earth every day, and are reduced to vapour. Were it not for the protection of our atmosphere, we should be subject to a continual bombardment which would render life difficult, even if we were so constituted as to be able to exist on an airless globe.

When the trails of a number of meteors appearing on the same night are continued backwards, it will be found that the majority appear to intersect at some definite point in the sky. This is known as the "radiant," and gives the direction in space from which the meteors are coming. The effect of perspective causes the paths to appear to diverge as the meteors approach us. A considerable number of meteor swarms have now been recognised, largely through the patient work of an amateur, Mr. W. F. Denning. They are named according to the constellation in which the radiant point is situated, *e.g.*, the Leonids, or "November" meteors, appear to radiate from a point in the constellation of Leo; the Cygnids from Cygnus; the Andromedes from Andromeda, etc., etc.

Although very bright meteors are comparatively few, the smaller ones are fairly numerous, and on an average, one would probably see 10 or 12 every hour on a clear night, given an uninterrupted view of the heavens. At times, however, they appear in great numbers, and on one occasion—9th October, 1933—I estimated that as many as between 500 and 1000 were flashing into view every minute.

Closely allied to the meteors are the *Comets*. On rare occasions one of these affords an impressive spectacle, as, for example, the great daylight comet of 1910, which presented a beautiful appearance in the western twilight. Its tail reached a length of about 22°, *i.e.*, equal to one-quarter of the arc from horizon to zenith, and at its widest part was four times the apparent width of the Moon.

The majority, however, are small and faint, and require a telescope for their observation. Even the famous Halley's Comet, which first appeared in 1066, and has revisited us at intervals of 70 years ever since, made a poor show at its last appearance, in 1910, at the same time as the great " Daylight Comet."

Another field in which the naked-eye astronomer can do valuable work is in the watch for "*Novæ*," or " new " stars. From time to time a new star suddenly appears, grows brighter, and then slowly fades away. The rise from obscurity to naked-eye visibility may only take a few days, and the maximum brightness is usually attained in a few days more. These Novæ are not, strictly speaking, *new* stars. They have been in existence for millions of years, but are, perhaps, too faint to be seen. For some reason, which we do not at present know, they become the scene of a tremendous cataclysm which causes them suddenly to shine out with hundreds of times their normal brilliance. Then they slowly die down, sinking back into obscurity.

The spectroscope shows the presence of intensely hot gases such as hydrogen, and often metallic vapours. Plenty of records are usually obtained of the declining stages of novæ, but far fewer can be secured of the earlier stages, since the time between discovery and the maximum phase is usually very short—indeed, the star not unfrequently attains its maximum brilliance before it is detected. Therefore, the star-gazer who spots a new star as soon as it becomes visible, and immediately notifies the nearest observatory, renders a great service to astronomy by enabling observations of the early stages to be made.

The search for new stars is one that can be combined with observations of the Milky Way, or of Meteors, and can be carried out by anyone who has a sufficiently intimate knowledge of the so-called fixed stars. It is a curious fact that the majority of new stars have appeared in or near the Milky Way.

Two quite bright novæ have appeared recently—Nova Herculis, 1934, and Nova Lacertæ, 1936—as well as several fainter ones.

Let us now turn to another class of star.

In the constellation of Perseus is a star known as Algol or Beta Persei. Normally this star shines as one of the second magnitude. But at intervals of approximately 69 hours it begins to fade, and in $4\frac{1}{2}$ hours has fallen to magnitude $3\frac{1}{2}$, *i.e.*, about one-third of its normal brilliance. It then begins to brighten up and in another $4\frac{1}{2}$ hours has regained its usual lustre. It was this peculiar behaviour which led the old Chaldean astronomers to name it Al-gol, the Demon. The cause of this periodic dimming is believed to be due to a dark star revolving round Algol in an orbit, the plane of which lies very nearly edge on to us, and consequently

Algol suffers a partial eclipse each time this dark companion passes between it and us.

There are other types of variable stars whose fluctuations are probably due to some change in the stars themselves.

Let us now take a hurried glance through the telescope at some of the celestial "sights," premising that each of the various objects chosen is but one of many which are available for study.

In the midst of the Milky Way, between the constellations Perseus and Cassiopeiæ, we note a tiny patch of brighter luminosity which reveals itself in the telescope as a glorious double cluster of stars, glittering like tiny jewels.

In the constellation of Andromeda may be seen another misty patch, which appears in the telescope as an elliptical glow, increasing in brightness towards the centre. It is known as the Great Nebula of Andromeda, and is believed to consist of an immense number of stars, situated at such an enormous distance that no telescope can reveal the individual bodies of which it is made up—in fact, it may be another "Universe" as large or larger than that of which our Sun is an insignificant member. The photograph shows a spiral structure, characteristic of many nebulæ of this class.

Theta Orionis, the middle star of Orion's sword, has a hazy look to the naked eye. With the telescope we see that it is made up of four stars close together, involved in a luminous cloud—the Great Nebula of Orion—which the spectroscope shows to consist of luminous gas—the raw material of the Universe.

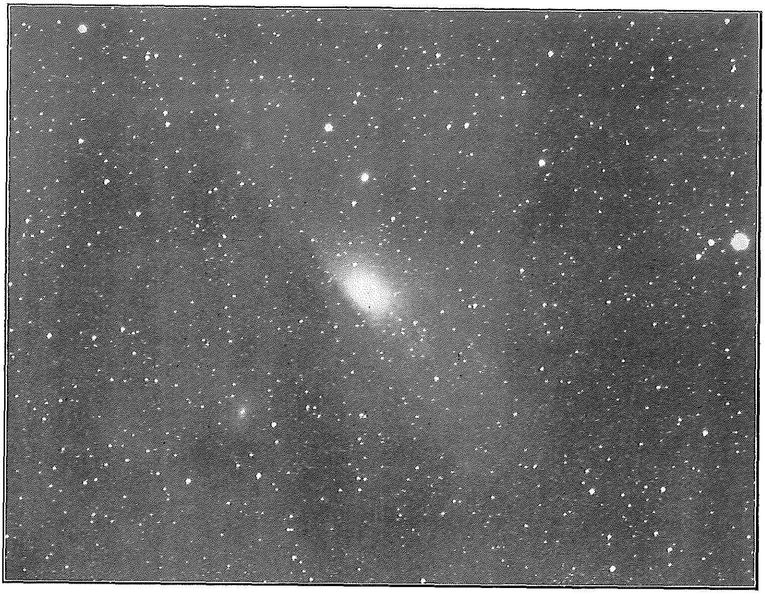
Beta Cygni to the naked eye is just a single star, but in the telescope it is seen to consist of two stars near together, the brighter being orange in colour and the fainter one blue. This contrast in tints makes it a most pleasing object. There are many thousands of double, triple, and multiple stars in the heavens, many of them having beautifully contrasted colours.

With the exception of Meteors and Comets, the objects which we have considered so far are denizens of the remote regions of space. Let us now return home and call on our next-door neighbours—neighbours so close to us that the most distant resides within a few thousand million miles of us—a mere stone's throw, astronomically speaking! We will visit the *planets* first.

The two innermost of these, Mercury and Venus, move in orbits of smaller radius than that of the Earth. All the others describe orbits outside our own. Consequently Mercury and Venus are never to be found very far from the Sun.

At the most favourable elongation, Mercury, the nearest planet to the Sun, never attains a distance of more than 28° from that luminary. It is therefore a difficult and rather elusive object and must be carefuly sought just after sunset or just before sunrise at the appropriate times if it is to be seen.

Venus, who at times of her greatest elongations is, *par excellence, the* morning or evening star, is perhaps the planet whose name is most familiar to the non-astronomical public. Owing to



Nebula in Andromeda.
Exposure 1 hour with 5 in. lens (Perth.)

Star Cluster in Perseus.
Exposure 40 minutes with 5 in. lens. (Perth.)

Plate XXXVII.

the greater radius of her orbit, she attains a maximum elongation from the Sun of 48°, and so becomes a very conspicuous object in a dark sky.

Apart from the Sun and Moon, Venus at her greatest brilliance is the most noticeable of all celestial objects and is distinctly visible to the naked eye even at noonday, provided that one knows exactly where to look for her.

Both Mercury and Venus exhibit phases similar to those of the Moon, and for a similar reason. At superior conjunction they would appear as "full moons," but as they are then lost in the Sun's rays we cannot see this phase. Similarly, at inferior conjunction they are at the "new moon" phase, and would not be visible even if not obscured by the glare of the Sun. The gibbous, "half-moon," and crescent phases of Venus are, however, easily observed, and there are few more exquisite objects than Venus shining as a delicate silver semi-circle low in the twilight sky.

No detail can with certainty be made out on the surfaces of these two planets.

Coming now to the Outer Planets, Mars shines with a ruddy light, which varies greatly in brightness according to his distance from us. When at his greatest distance he appears no brighter than a second magnitude star such as the Pole Star, but when he approaches us most closely he shines with a brilliance fifty times as great, and has been said to cast a perceptible shadow.

Our little telescope will not reveal much detail on his surface. We may see one or other of the polar "snow caps," which vary in size according to the Martian seasons. If circumstances are favourable, faint markings may also be seen on his surface, and if a watch be kept on these it will be seen that Mars is revolving on its axis at very nearly the same rate as our Earth.

Outside the orbit of Mars revolves the giant planet Jupiter, whose diameter is more than ten times that of the Earth. To the amateur, this is perhaps the most interesting of all the planets, for not only does his large size provide a sufficiently large disc to make an interesting picture in a small telescope, but the varied phenomena exhibited by Jupiter and his attendant satellites present an ever changing spectacle. Our three-inch telescope will reveal two or more dark belts crossing the disc, parallel to the equator, and if conditions are good some detail may be made out. A careful watch will soon show evidence of rotation, markings moving from east to west across the disc in the course of a few hours.

Jupiter has four satellites, or "moons," which are easily visible in the smallest telescope, or even in a good prismatic binocular. There are also several very tiny ones only visible with very large instruments. The four larger "moons," which are all somewhat larger than our own Moon, appear as little stars grouped in the planet's equatorial plane. Sometimes we see all four strung out in a line on one side of their primary. At other times some will be on one side and some on the other. Their periods of revolution around Jupiter range from 1 day 18½ hours to 16 days 18 hours. Consequently they present an ever changing pattern and quite a short watch will reveal their movement.

Closely rivalling Jupiter in interest for the possessors of small telescopes comes Saturn, unique among the planets by reason of its encircling rings. With our three-inch telescope we see a disc rather like a miniature edition of Jupiter, crossed by faint shadings like belts. The equatorial zone is decidedly brighter than the rest of the planet so as almost to appear as a white belt. But the outstanding feature is the ring system which encircles the planet. This is in the form of a very thin flat disc with a hole in the middle occupied by the ball of the planet. The outer diameter of the rings is about 2¼ times the equatorial diameter of the planet, while their thickness is so small that when seen edgewise they are invisible in all but the very largest telescopes.

Saturn is known to have nine "moons," but only two or three of the largest of these are within reach of our telescope.

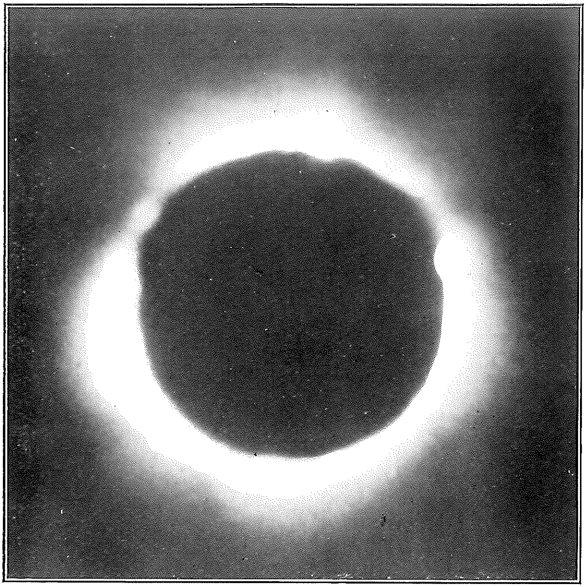
The two outermost planets (ignoring the recently discovered Pluto) are of little interest to us. Uranus appears as a tiny greenish disc in our telescope and is just visible to good eyesight without optical aid as a very tiny star. Neptune can only be seen with a telescope and can barely be distinguished from a faint star with the instrument we are using.

And now, what of the Moon, the nearest of all celestial bodies and second only in importance to the Sun, so far as we Earth-dwellers are concerned?

Our Satellite revolves round the Earth once in 27 days 7 hours, but owing to the movement of the latter in its orbit, the period between two successive "full moons" is 29½ days. The Moon also turns on its axis on exactly the some time as her period of revolution round the Earth. Consequently she always presents the same side to us. If we observe the position of the Moon in relation to that of some bright star near her, we shall see that she is moving eastward among the stars, at a rate which carries her a distance equal to her own diameter in about an hour. Consequently she comes to the meridian about three-quarters of an hour later each night.

In the course of her journey round the Earth, the Moon from time to time passes in front of the various stars which lie in her path—in the language of the astronomer she "occults" them. Except in the case of the brightest stars, these occultations require a telescope for their observation.

When the Moon is at crescent phase we often see the whole of the disc faintly showing. This phenomenon, which is popularly known as the "old moon in the new moon's arms," is due to the illumination of the dark part of the disc by light reflected from the Earth, for to a dweller on the Moon, the Earth would appear as a large "moon" nearly four times the diameter of our satellite as seen by us. It would also present the same succession of phases



TOTAL SOLAR ECLIPSE, 29TH JUNE, 1927. CORONA.
5 secs. exposure, f/15, green screen, supersensitised panchro. plate. (Photographed at Dalehead, Yorkshire.)

MOON. $12\frac{1}{2}$ DAYS OLD.
9 secs. exposure with 3 in. Telescope and "Astra" filter. (Perth.)

PLATE XXXVIII.

that the Moon shows us. With the naked eye little can be seen of the topography of the Moon. She appears as a silvery disc, mottled with greyish patches. But with the telescope she is an object of unrivalled beauty. The greyish patches seen with the unaided eye are revealed as extensive plains. They were formerly believed to be expanses of water, whence their names—Mare Crisium—the sea of Crises; Mare Tranquilitatis—the sea of Tranquillity; Mare Imbrium—the sea of Showers; Oceanus Procellarum—the sea of Storms; Sinus Iridum—the bay of Rainbows; etc., etc. It is now known that there is neither air nor water on the Moon, but the original names are still used.

Bordering these plains are numerous mountains of volcanic appearance, standing singly or in ranges. Here and there a great volcano rises from the surface of the plains in majestic isolation, while a closer scrutiny reveals numerous tiny craterlets, many of which appear to be depressions in the floor of the plain rather than excrescences. Deep fissures miles in length are seen in some places. The craters have nearly all the same form—a more or less flat circular basin surrounded by a high ridge and having a conical mountain in the centre. In many cases one crater is superimposed on another, apparently due to successive volcanic outbursts in the same neighbourhood. The floors of the larger craters are frequently studded with minor craterlets.

A striking feature of lunar scenery is the density and sharp outline of the shadows, due of course to the absence of any atmosphere. There is no twilight on the Moon.

The lunar mountains are best seen when near the "terminator," the irregular line which divides the lunar day and night. In this situation, illuminated by the nearly horizontal rays of the rising or setting Sun, the brilliantly lighted sunward slopes contrast vigorously with the dense shadows cast by the various elevations and enable one to envisage a three dimensional picture.

As the Moon's phase waxes and the Sun rises higher and higher over her western areas, the shadows shorten, until at full moon they disappear altogether. Under these circumstances we can make out little of the irregularities of her surface, for the only contrast is provided by the grey tone of the plains in comparison with the more brilliant reflections from the highlands.

There are, however, certain features which are best observed at full moon. Of these the most remarkable are the curious bright streaks which radiate from some of the largest craters, notably from Tycho, Copernicus, Kepler, and Aristarchus.

As the Moon wanes the shadows reappear on the opposite sides of the peaks.

Lunar eclipses, especially total ones, provide a very interesting spectacle, which may be appreciated by the naked-eye astronomer equally with his optically-aided brother. During total eclipse, the Moon may be seen glowing with a dull coppery light. This is due to the refraction of the Earth's atmosphere bending some of the

Sun's rays sufficiently to cause them to impinge on the lunar surface. The red colour is caused by absorption of the shorter wavelengths of the sunlight in our atmosphere, so producing a reddish "sunset" effect.

The Sun does not yield many of his secrets to the unaided eye. On rare occasions, however, the Sun in conjunction with the Moon provides the most impressive and awe-inspiring spectacle in Nature —a *total* Solar eclipse. I do not think that anyone who has witnessed one of these occurrences could ever forget it. As the Moon in her orbit passes between our eyes and the Sun, the latter presents an ever narrowing crescent until, at the critical moment of totality, the last vestige of the brilliant orb is hidden. Then, and only then, is the wonder of a total eclipse revealed, for the black disc of the Moon is encircled by a vivid scarlet ring, from which rise tongues of scarlet flame, while surrounding all and extending to a considerable distance, shines the mysterious pearly light of the Corona.

Unfortunately total Solar eclipses are only seen from places lying within narrow tracks on the Earth's surface, and these tracks rarely cross the British Islands. The last total Solar eclipse visible in Britain took place in June, 1927, when the path of the eclipse crossed Lancashire and Yorkshire. The width of the track was only ten miles, and I had the good fortune to be living on the centre line, and moreover was luckier than most in having a patch of clear sky at the critical moment, whereas others only two or three miles away saw nothing.

The Sun nearly always presents something of interest to the amateur who is equipped with a telescope. It is, of course, necessary to take special precautions when using a telescope on the Sun, owing to its intense light and heat. With telescopes up to two inches in aperture, a simple dark glass fitted over the eyepiece is sufficient, but for a three-inch telescope a "solar diagonal" or other special apparatus is necessary. Alternatively, the Sun can be viewed by projection on to a white screen.

If we examine the Sun on any day at present we shall almost certainly see one or more "spots," large or small; and if we continue to observe for a period of years we shall find that the spots gradually become fewer and fewer after this year, until in about five years' time hardly any are to be seen for weeks or months on end. Then they will begin to reappear, becoming by degrees larger and more numerous, until about 1948, when they will again have reached a maximum, after which they will diminish again.

The sunspot cycle covers a period of 11 years. Certain terrestrial phenomena appear to fluctuate in sympathy with this 11-year cycle. For example, as the sunspot period approaches its maximum the auroral displays extend to greater distances from the Earth's poles, and consequently are more frequently seen in our latitudes.

In the telescope, sunspots appear as a black central portion known as the "umbra," usually surrounded by a grey shading known as the "penumbra." Under a high power the penumbra is seen to consist of filaments, like tongues of white flame, springing from the white "photosphere," as the visible surface of the Sun is called, and appearing to overhang the dark umbra. Not infrequently a bright tongue projects far out over the dark spot or even completely bridges it.

If we watch a spot from day to day we shall notice that it moves from east to west across the face of the Sun. This is due to the fact that the Sun rotates on its axis once in about 25 days.

In addition to spots we see curious patches and streaks of even greater brilliance than the general surface of the Sun. These "faculæ," as they are called, are particularly noticeable near the edges of the Sun's disc, and are due to intense eruptions of incandescent matter. They are usually associated with spots.

In conclusion, I would like to draw your attention to two other phenomena, which particularly come within the province of the naked-eye astronomer, for they are both of a nature which renders the telescope useless for their observation.

The first of these is the *Zodiacal Light*, or "Afterglow." It consists of a faint semi-elliptical-shaped pearly glow which is best seen after sunset at the end of February or before sunrise at the beginning of October. Its real nature has not yet been settled, and there is room for serious work in this direction.

The other phenomenon is not, strictly speaking, a celestial one, since it manifests itself within the bounds of the Earth's atmosphere, but it is one well adapted for naked-eye work. I refer to the *Aurora*. Although what we might term a local affair, it is closely associated with solar activity and varies in form and behaviour with the sunspot cycle.

XLII.—THE SCOTTISH CORONATION STONE.

By A. Rutherford.

(Read 8th January, 1937).

As is well known, the Stone of Destiny, the palladium of the Scottish people, lies under the seat of the Coronation Chair made for Edward I. of England, in Edward the Confessor's Shrine in Westminster Abbey. It is an oblong block of *red sandstone*, about 26 inches long by $16\frac{3}{4}$ inches broad, and $10\frac{1}{2}$ inches in depth. For lifting it, there is an iron ring fastened at each end. It is a good deal worn with handling, and bears no engraving or inscription.

The stone has both historical and legendary interest. Historically it is a fact that it is the Stone which Edward I. of England carried to London, along with the Holy Rood, or Cross of St. Margaret, and all documents or papers which might show that Scotland was an independent kingdom. We also know that it is the Stone on which John Baliol was crowned King of Scotland at

Scone in 1292. It is also the same Stone on which Alexander III., a boy of eight years, was crowned king of Scots in 1249, and it is probably the Stone which was in use at the coronation of earlier kings, although we have no reliable account of this. But that is all we know historically about the Stone.

As regards the legend, the most complete version is that given by Hector Boece, first Principal of Aberdeen University, who wrote in 1527:—Gathelus, a Greek, went to Egypt at the time of the Exodus, where he married Scota, the daughter of Pharaoh, and after the destruction of the Egyptian army in the Red Sea, fled with her by the Mediterranean till he arrived at Portugal, where he founded a kingdom.

Here he reigned in the *marble* chair, which was the fatal Stone like a chair, and wherever it was found portended kingdom to the Scots. In after ages it *bore the following inscription in Latin,*

"Unless the Fates be faithless found,
And prophet's voice be vain,
Where'er this monument be found,
The Scottish race shall reign."

Simon Breck, a descendant of Gathelus, brought the chair from Spain to Ireland, and was crowned in it King of Ireland. Fergus, son of Ferchard, was first king of the Scots in Scotland, and brought the chair from Ireland to Argyll. He built a town in Argyll, called Beregonium, in which he placed it. From him proceeded forty kings of Scotland. The twelfth king, Evenus, built a town near Beregonium, now called Dunstaffnage, to which the Stone was removed. When Kenneth MacAlpine, the last of these kings, conquered the Picts, he brought the fatal Stone from Argyll to Gowry, and placed it in Scone, because it was there that his principal victory over the Picts had taken place.

This legend is discredited for several reasons. The Stone in the legend is said to have been of marble; as a matter of fact it is composed of red sandstone. In the legend, it is said to have had a design and inscription engraved on it, but the Scottish Stone has neither. There is no red sandstone at Bethel, where it is said to have come from originally, or at Iona, one of its alleged resting places.

Besides, the legend regarding the Stone first appears in a statement prepared for the Pope's information in the dispute between the English and the Scots in 1301. The English informed the Pope that the Scots had always been subject to them, since both races were descended from Brutus the Trojan, but the English were descended from the eldest son, while the Scots were descended from the youngest son. To this, Baldred Bisset, the Scots Commissioner, opposed the story of the descent of the Scots from Pharaoh's daughter, and their mythical wanderings through Spain and Ireland, and he supported it by giving a fictitious history to the Coronation Stone at Scone.

It is generally believed by antiquaries that we owe the origin of the legend regarding the Stone entirely to the patriotic ingenuity of Baldred Bisset.

So far as I can find, there is no reliable information regarding the origin of the Coronation Stone.

We know that stones, as places of worship, were sacred to the Druids—even to-day, Highlanders speak of worshipping at the Clachan, or the stones. It was the custom of the Celts and other ancient peoples to inaugurate kings or chiefs on a sacred stone, supposed to symbolise the strength and stability of the monarchy. The Irish kings were inaugurated on the *Lia Fail* at Tara. Down to the time of Gustava Vasa, the kings of Sweden were inaugurated on the "great stone," still visible on the grave of Odin near Upsala, and it is on record that seven Anglo-Saxon kings were crowned on the "King's Stone," now the modern Kingston-on-Thames.

It is, therefore, most probable that the Stone at Scone was a Tanist stone, where the new chief or king was elected and sworn to protect and lead the people. This custom is believed to be of Eastern origin, and is traceable to a very remote era. There are several traces of it in the Old Testament. In Judges 9: 6, we are told that "the men of Shechem gathered together, and made Abimelech king by the *pillar* which was in Shechem," and in 2 Kings 11: 14, we read, "when Joash was anointed king he stood by *the pillar, as the manner was.*"

I conclude, therefore, that the Stone which Edward I. carried to England in 1297, and on which John Baliol and Alexander III. were crowned, was the inauguration stone of the Pictish monarchy, and stood at Scone, their Capital, and its use was continued by the Scots when they became predominant in the country. Such stones were regarded as essential by all the Celtic tribes, whether of Alban or Ireland. The Stone is almost certain to have originated at Scone. The sandstone it is composed of is similar to that found in the district.

We venerate that plain piece of red sandstone in Westminster Abbey, and the bardic prophecy is still true, for never in the last three hundred years has the throne of Great Britain been more Scottish than it is to-day.

See *Proceedings of the Society of Antiquaries of Scotland,* Vol. VIII. (1869)
—Dr. W. F. Skene.

Illustration on Plate XXXIX.

XLIII.—THE GEOLOGY OF THE CORONATION STONE.

By C. F. DAVIDSON.

The Coronation Stone is a roughly rectangular block of coarse-grained sandstone, reddish-grey in colour, which is kept in Edward the Confessor's Chapel in Westminster Abbey, enclosed in a box-like space under the seat of the Coronation Chair. This chair, on which the kings of Britain are crowned, was constructed in 1300-01 by Walter, "King's painter" to Edward I., to contain the stone which that monarch had lately removed from Scone, the capital of Scotland. The stone is roughly hewn, and measures approximately 26½ inches long, 16½ inches broad, and 11 inches thick. The top surface is worn smooth, as if by long exposure, and has at each end a rectangular sinking to contain iron staples and rings, which are so placed that a pole may be passed through the rings for the convenient transport of the stone. Hollows, which may be attributed to the wearing down of the stone through friction with the pole, can be seen on close inspection. It is probable that the insertion of these rings was carried out at the time of Edward I. At an earlier period the top surface of the stone appears to have been marked for a rectangular depression, which was never carved out, while behind this, centrally situated, is a small, rough cutting in the shape of a Latin cross. Apart from these markings, there is no engraving or inscription on the stone.

The stone has been examined by successive generations of geologists, including John Macculloch, Sir A. C. Ramsay, Sir Archibald Geikie, and Sir J. J. H. Teall. From these investigations it has long been known that the stone is almost certainly of Scottish origin, but its lithological character is such that it has always been found a difficult matter to trace it with any certainty to the locality from which it was first quarried.

Recently, the writer has had an opportunity of examining microscopic preparations of minute fragments obtained from the stone while it was being cleaned in the year 1892. These have been compared with similar preparations of rocks from various localities and geological horizons, and from this study the Coronation Stone is seen to agree most closely in lithology with sandstones of Lower Old Red Sandstone age from Scotland. Several examples of sandstone petrographically indistinguishable from the Stone of Destiny have been collected from the vicinity of Scone itself—for example, from the rocks of Quarrymill Den.

One or two small pebbles of porphyrite or andesite, about the size of a pea, may be seen in the stone at Westminster. Similar pebbles are frequently found in the Lower Old Red sandstones throughout Scotland, and are not uncommon in the rocks in the neighbourhood of Perth and Dundee. A microscope section of a pebble from the Coronation Stone has been examined, and although rather decomposed, this pebble is undoubtedly very similar to porphyrites of Lower Old Red Sandstone age, and can be matched with pebbles from the sandstone rocks of Perthshire and Angus.

There is a widespread belief that the Stone of Destiny was once kept at Dunstaffnage in Argyll, and was originally quarried somewhere in this area; but this appears to rest solely upon the statement of Boece, the Scottish historian, and as there is no authority for this view in any of the earlier Scottish chroniclers, like much of Boece's writings it must be regarded at fabulous. John Macculloch, however, notes in his "*Description of the Western Islands of Scotland*" that "the stone in question is a calcareous sandstone exactly resembling that which forms the doorway of Dunstaffnage Castle." To investigate this the writer paid a visit to Dunstaffnage. The development of the Old Red Sandstone in this district is predominantly volcanic, but of the sediments very coarse-grained conglomerates and breccias are much more abundant than sandstones; and, compared to eastern Scotland, there are relatively few localities from which a sandstone block the size of the Coronation Stone could be conveniently quarried. The walls of Dunstaffnage Castle are formed of boulders and rudely-dressed blocks of the local schists and andesites, and if a "royal seat" had been quarried in this neighbourhood, one might reasonably expect it to be of these rocks rather than of sandstone.

The rocks which form some of the corner stones, and the voussoirs of the doorway of the castle, to which Macculloch refers, do not appear to be of local origin. They resemble more closely desert sandstones of Triassic age, such as those from Carsaig in Mull, and are quite different from the Coronation Stone. Triassic sandstones of similar character have already been noted in important Hebridean buildings of medieval date, such as Iona Cathedral and the Rodel Kirk in South Harris.

The historical evidence given by Skene and others appears to indicate that the Coronation Stone was not in use at any place other than Scone prior to its removal by Edward I., and it is to be expected, therefore, that it was of local origin. The geological evidence here given is in accordance with this view, and we can thus assume with reasonable certainty that the stone was quarried somewhere in the east of Perthshire or in southern Angus, probably not far from the ancient seat of the Pictish monarchy at Scone.

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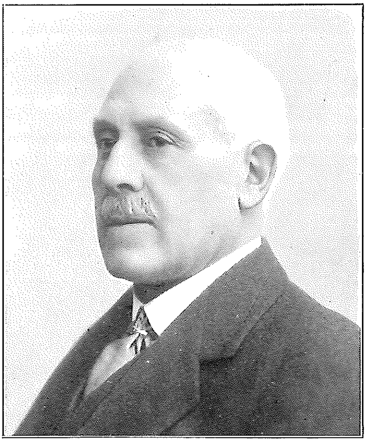
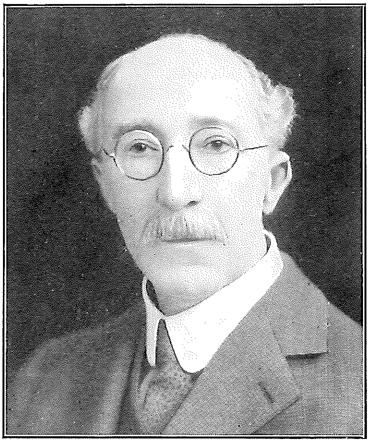
Illustration on Plate XXXIX.



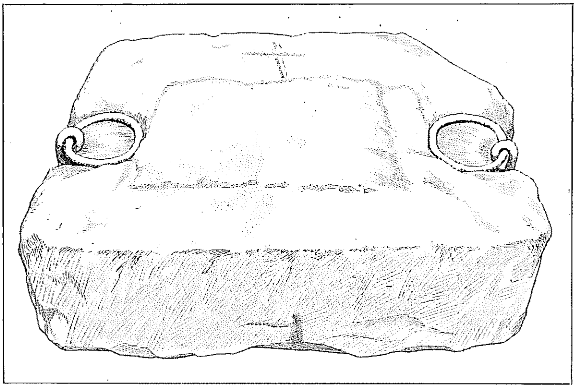
G. P. K. Young.

Surg.-Capt. C. G. Matthew.



Henry Coates.

Robt. H. Meldrum.



Coronation Stone.

Plate XXXIX.

VOL. IX. PART VII.

CONTENTS.

XLIV.—A PROBABLE CELTIC HILL FORT ON WHITEFIELD HILL, KIRKMICHAEL, IN STRATHARDLE.

By A. RUTHERFORD.

Reference—6″ Ordinance Survey Map, Sheet XXXII., N.E.
Approximate Long. 3° 29′ 14″; Lat. 56° 44′ 13″.

In 1922, the late Mr. R. Boag Watson discovered a British hill fort, 96 yards long and 44 yards wide, on Deuchny Hill, just above Corsiehill, Perth, and for his discovery he was awarded the Chalmers Jervaise prize. His paper on the subject is included in Volume 57 of the Proceedings of the Society of Antiquarians of Scotland for the year 1922-23. In the following summer, Mr. Boag Watson invited the members of the Perthshire Natural Science Society to see the fort. I was one of the company, and as Mr. Boag Watson pointed out the various objects of interest—the entrance, the walls, the place where the well had been—it became quite apparent that an ancient hill fort had formerly occupied the site.

In August, 1937, I spent a holiday at Kirkmichael, and one day climbed to the top of Whitefield Hill, which rises on the north immediately behind the village to a height of 1,400 feet above sea level. When coming down I noticed, at about 100 feet from the top, on the most westerly knoll of the hill, traces of mounds and earthworks very similar to those at Deuchny Hill fort—the two bore such a close resemblance to each other that one could only come to the conclusion that it was a hill fort of the same type as that on Deuchny.

On returning to Perth, I mentioned the matter to Mr. Ritchie, director of the Museum, and others, and as a result several members of the Perthshire Society of Natural Science went to Kirkmichael one afternoon to see the place. Beyond the village they turned to the right by the avenue to Dalnagairn House, and went straight up the hill. The knoll on which the fort was situated was immediately in front. On its west side it rose steeply to between 30 and 40 feet above that part of the hill. On the north-west side the party found a well-defined entrance or gateway. It entered the fort obliquely. Entering, the structure was found to be oval in shape. The extreme length was 299 feet, and the breadth at the widest part 110 feet. About the middle of the fort there was a hollow damp place, overgrown with rushes, which was probably the remains of a well. There were traces of a wall right round the knoll, say, about two feet high and two feet in width. Inside the fort were traces of three buildings of rectangular shape. There was also evidence on the eastern side of a ditch, which had probably been made for defence. Stretching out from the fort on the north-east and south-east there were long mounds or ramparts. These were probably for the safety of the cattle when the fort was attacked.

From a strategic point of view, the place where the fort was situated was admirable. From the southmost wall one could see away to the south, down Strathardle, for many miles, and to the east one could see Dalrulzeon in the Blackwater district of Glenshee. That was to say, no enemy could pass up either Strathardle or Glenshee without being seen from Whitefield fort.

As the site was not examined, no artifracts were found. I offer the opinion that the structure on Whitefield Hill belonged to the early Iron Age between, say, 100 B.C. and 100 A.D., during which period many of the Celtic tribes retreated before the Roman armies to the fastnesses of Caledonia. It might be later than that, but it was certainly a place of defence of a primitive people. The district around Kirkmichael is rich in archæological remains which are well worth investigation.

An interesting discussion followed the paper. Mr. M'Leman, who was one of the party to visit Kirkmichael and who has seen other hill forts, gave it as his opinion that the structure on Whitfield Hill was a Maiden Fort of the Iron Age. Mr. C. F. Davidson, H.M. Geological Survey, considered it possible that the structure was an ancient hill fort. Mr. J. Ritchie was not inclined to date the fort so far back as the first century, but thought it might be merely a ruin older than Whitefield Castle nearby, which dates from 1577.

XLV.—ORTHALICUS ZEBRA.

By W. Davidson.

Among the animals sent in to the Museum this year was a live snail, which came to this country with a consignment of bananas from Jamaica.

The snail, which was identified as Orthalicus Zebra, measured two and one-quarter inches from the edge of the lip to the apex, and one and one-quarter inches at the greatest diameter. It had a pearly-white ground colour with black vertical lines running along the length of the shell. The shell may be described as a coiled hollow cone, the turns of the spiral being right-handed. In very rare cases the spiral may be left-handed or reverse.

This is a terrestrial or land snail and inhabits the tropical parts of America and the West Indies, being found in the forest areas. The eggs are glued on to the underside of the leaves of its natural food plant.

It possesses two pairs of tentacles, the top pair bearing the eyes, and the lower pair are the sensitive organs of touch. The tentacles are so transparent that on touching the snail the black eye bulb can be seen descending down through the shortening stalk until concealed under the skin of the head.

XLVI.—SOME OBSERVATIONS ON THE WEATHER OF PERTH (1883-1936).

By Kenneth M. MacAlpine, M.A.

In the 1909 Transactions of the Society, detailed statistics were given of the weather in Perth from 1883-1908. A somewhat similar summary for the period 1909-1936 is now shown, and certain observations on these figures are added. As the two periods are of practically the same length, comparison may be made quite appropriately.

The monthly figures, which have been used as a basis for comparison, have of course certain inherent weaknesses. A calendar month is an artificial division of time, and average figures for a month may include very diverse types of weather: it is rather unusual for the weather to remain similar throughout a whole month.

In some cases, seasons are mentioned. For the purpose of this survey the year has been divided into seasons of three months each, Spring being March, April and May; Summer—June, July and August; Autumn—September, October and November; and Winter—December, January and February. This grouping again has something of the artificial about it, but it is much to be preferred to the now almost obsolete division of the year into such periods as the intervals between equinox and solstice.

Some of the observations made refer directly to Perth only, while others may be taken to refer to Scotland as a whole.

The total period examined amounts to just over half-a-century, a period probably much too short to show clearly the existence of weather cycles, or even to arrive at very accurate averages for weather.

During this comparatively short period, too, certain changes in the location of the weather recording station have unfortunately been made, and, while these may not have had any very profound effect on the figures, they cannot but have had some influence. The differences, if any, are more likely to appear in the temperature figures than in the rainfall ones.

TABLE A.—EXTREME AVERAGE TEMPERATURES PER MONTH.

	Warmest. Year.	Warmest. °F.	Coldest. Year.	Coldest. °F.
Jan.	1898	43.3	1895	30.8
Feb.	1903, 1914	42.8	1895	27.0
Mar.	1927	43.9	1888	35.1
Apr.	1896	48.8	1922	41.1
May	1896	55.6	1902	46.2
June	1933	59.0	1888, 1907, 1928	52.1
July	1901	63.1	1888	54.2
Aug.	1911	61.4	1912	53.7
Sept.	1895	57.8	1918	49.4
Oct.	1908	52.2	1896	42.2
Nov.	1897	45.7	1919	34.1
Dec.	1924	43.9	1886	31.4

The absolute range of temperature in the shade for Perth over the whole period is 97° F.—from 90° in July, 1911 to $-7°$ in November, 1919. This range, when compared with the average monthly range of about 21°, from January (37.5°) to July (58.8°), may seem at first rather large, but taking into account Perth's position, inland rather than coastal, the range is not excessive compared to other parts of Scotland. In an average year the absolute range would seem to be somewhere in the neighbourhood of 70° or rather less: this extreme range, like the average monthly range, is somewhat greater than that for Dundee, and much greater than for places on the western coasts of Scotland.

The highest monthly mean recorded within the period was in July, 1901, when the average temperature was 63.1°, over 4° above normal, while the lowest mean for any month was in the extremely cold February of 1895, when the average temperature fell as low as 27.0°, almost 11° below normal. If these figures were the rule rather than the exception, then Perth's climate would resemble very closely that of Southern Sweden, *i.e.*, it would be of a modified Continental type.

TEMPERATURE.

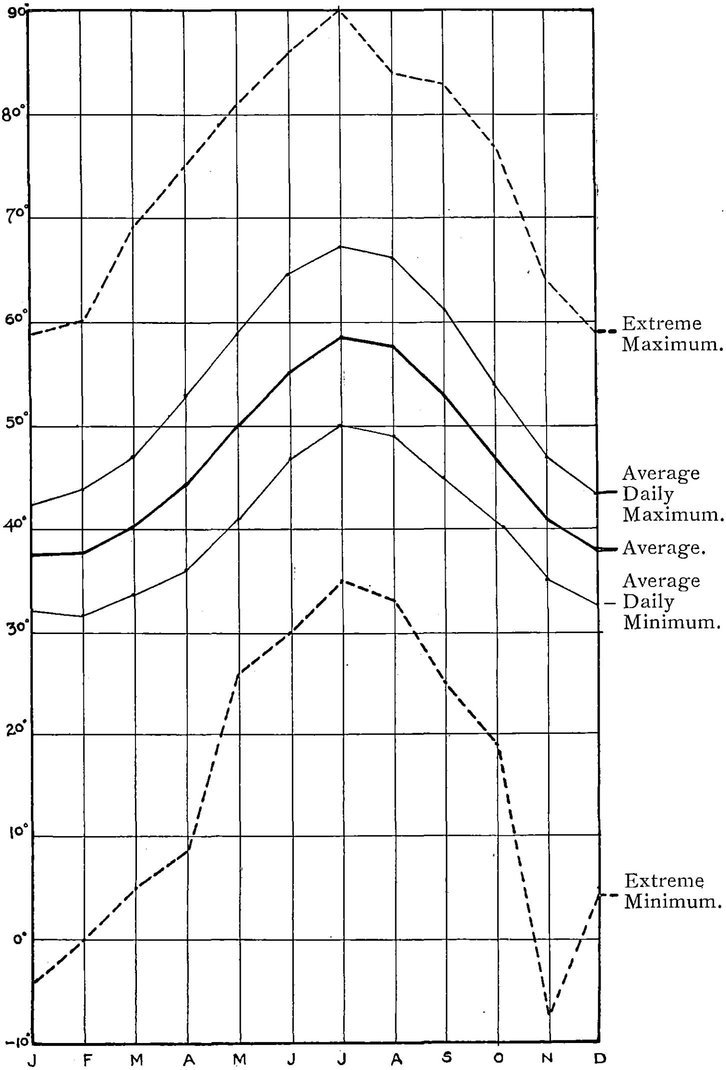


Plate XL.

TABLE B.—ABSOLUTE EXTREME TEMPERATURES.

	Warmest.		Coldest.	
	Year.	°F.	Year.	°F.
Jan.	1890	59°	1894	−4°
Feb.	1897, 1918	60°	1895	0°
Mar.	1893	69°	1917	5°
Apr.	1914	75°	1908	8.5°
May	1908	81°	1906	25°
June	1925	86°	1888, 1918	30°
July	1911	90°	1918	35°
Aug.	1893	84°	1892, 1916, 1921, 1932	33°
Sept.	1898	83°	1928	25°
Oct.	1926	77°	1909, 1911	19°
Nov.	1933	64°	1919	−7°
Dec.	1900, 1921	59°	1899	5°

The extreme range per month is interesting. November shows the greatest range with 71°, due largely to the extremely low temperature in 1919, which was about 17° colder than any other November before or since. The smallest range is shown by August with 51°. Thus we see that every month in the year is subject to very considerable fluctuations of temperature, with no one month being very outstanding in this respect. There are only two months in the year, July and August, when frost has not been recorded in the screen, and in both of these months ground frosts have occurred.

It is perhaps worthy of note that only on two occasions does it happen that the month with the lowest average temperature is also the month with the extreme lowest temperature: these are the very cold months, February, 1895, and November, 1919. There is no case at all of a month with the highest average temperature having also the highest maximum. Extremes of temperature do not seem to come in the midst of long-continued spells either of particularly hot or of particularly cold weather. July, 1911, with the highest maximum on record (90°) had also the second lowest minimum ever recorded for the month (36°).

Winter months tend to show a much greater range of average temperature than summer months: February is greatest with a range of 15.8° and June least with 6.9°. This can largely be explained from the fact that the absence of S.W. winds has a much greater effect in winter than in summer; thus a calm July is likely to be a little warmer than a July with winds blowing from the sea, but a calm January will as a rule be very much colder than one with frequent mild westerly gales. During exceptionally mild winter months, indeed during almost all winter months, we are "borrowing" heat from more southerly latitudes, and direct sunshine affects our temperature very little. In summer we are getting warmth directly from the sun, and this warmth is tempered somewhat by a wind blowing from a sea which has not heated up so much as the land.

In comparing the two periods under consideration we find that the second period shows an increase of average temperature in every month except September and November, though occasionally the increase is small. This increase is possibly due in part to changes in the location of the weather recording station and not wholly to any great variation in climate.

It seems, however, that while the increased winter temperatures have been accompanied as a rule by increased rainfall, the increased summer temperatures have been accompanied by a decreased rainfall. This state of affairs may then be due to a greater frequency of westerly winds during the winter months and a lesser frequency of them in the summer half-year. Unfortunately the existing wind observations do not afford any satisfactory basis for comparison, it being only too obvious, particularly in the first period, that a change in the personnel of the recorders has produced a change in the wind! As there has been no very accurate wind recording station for Perth, the wind records have been disregarded in the comparison of the two periods.

The most considerable increases in average temperatures between the two periods are shown in February, which is 1.27° warmer in 1909-1936, and in July and August, which show an almost similar increase. The lowering of temperature shown in September in Perth is not shared by the South of Britain, where there have been many heat waves in that month in the past twenty-five years. Some particularly cold Novembers in the second period have lowered the general average for that month.

An attempt has been made in the accompanying Graph to show the variations from the average for the period, both as regards three-month seasons and for the whole year. It seems from the annual variation wave that there is some little support for a cycle of about eight years, but at best this is a rough generalization. If statistics had been available for a much greater length of time, then the existence of weather cycles might have become more apparent. If the averages now arrived at for the different months are more or less the true ones, then it might seem that we are due to have a preponderance of months colder than the average for the next few years, but it is not obvious whether this would mean a general lowering of temperature right throughout the year or only for certain seasons.

If we examine statistics—which, after all, are usually more reliable than one's memory—we find that the variability and uncertainty of our weather is no new thing.

The contention that our winters are milder now than forty years ago has evidence to support it. Of the five months, November to March, which can best be classed as winter, it is noticeable that all except November show the lowest average temperature in the closing years of last century, while the warmest winter months are

GRAPH SHOWING SEASONAL VARIATION OF TEMPERATURE.

Shaded portions indicate preponderance of months colder than average.
Unshaded portions indicate preponderance of months warmer than average.

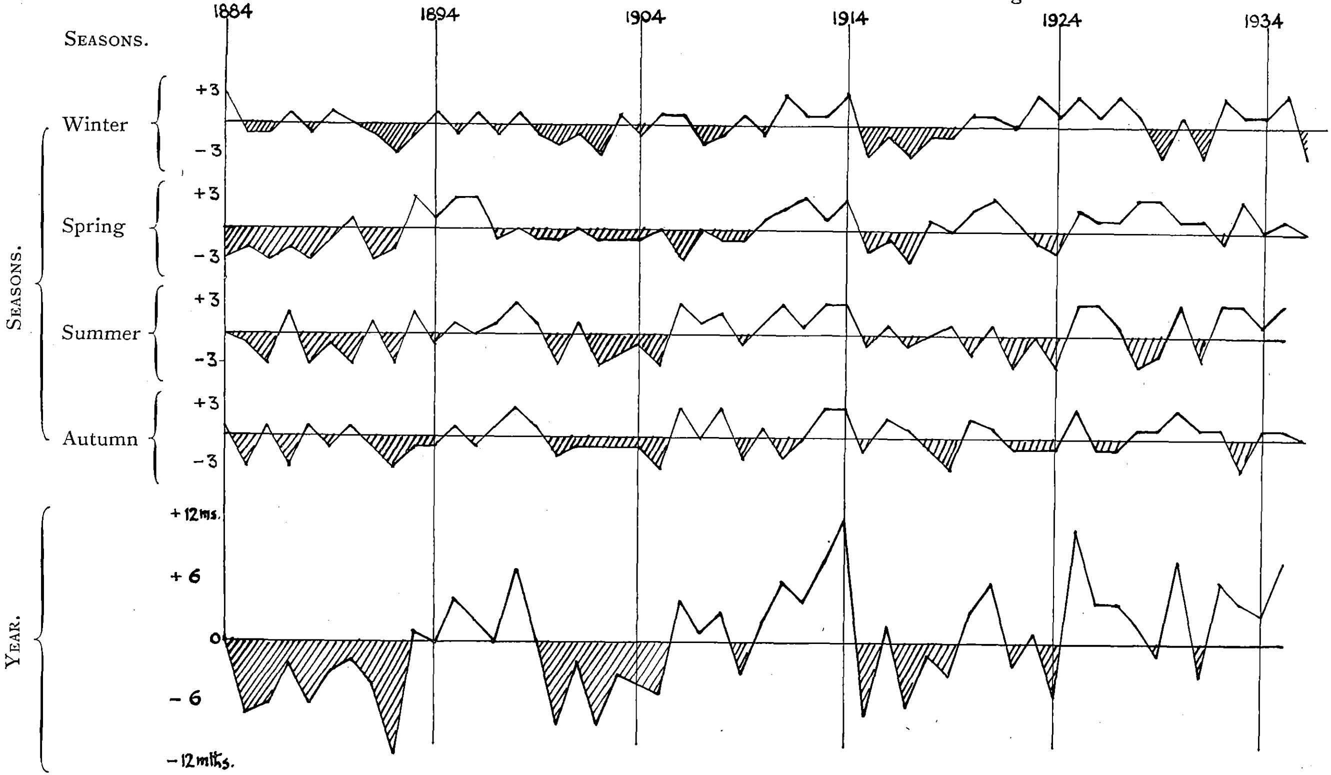


Plate XLI.

more evenly divided between recent years and the earliest years of the period for which records have been kept in Perth. There was certainly a period, from 1919 to 1928, when the winters were much warmer than the average, but in the past few years the winters have as a rule been almost if not quite of the "old-fashioned" type.

There were years at the close of the nineteenth century with periods of frost unequalled in recent times, but they were few. It might be mentioned in passing that one thing which makes modern winters appear rather less severe is the fact that nowadays a far greater proportion of our population is urban, and so does not see the worst effects of blizzards, and also, with the great increase in road traffic, snow is prevented to some extent from lying on main roads, or if it does lie is of necessity cleared away with greater expedition. This explanation, of course, will refer rather to snow only and not to frost.

It does seem very clear that in more recent years the summers have been rather warmer than they were towards the close of last century, but of course there have been exceptions to this general tendency.

As mentioned already, there appears to be little evidence of regular weather cycles, but certain sequences of weather are perhaps worthy of notice, *e.g.*, in the six years between 1894-9, severe winters some of these, each November was warmer than the average, and three of them in that spell were the mildest ever recorded. Again, nine Aprils in succession (1884-1892) were colder than the average, while in the next nine years only two were colder. From 1920-1928 each February showed an average temperature above normal, a sequence which was broken in 1929 by one of the coldest months for thirty-five years.

The longest period of successive months showing temperatures above the average was from May, 1913, to November, 1914, nineteen months in all. Fortunately there has never been such a long spell of weather colder than the average.

The statement that unseasonably warm weather will be followed by a particularly cold spell does not appear to be borne out by the records. At the same time it is only natural that if weather is considerably warmer than the average at one period, a resumption of normal weather conditions later on will give the appearance of a compensating cold spell. It does happen that sometimes a month which is exceptionally warm one year may be exceptionally cold the next, *e.g.*, the hottest July on record (1901) was followed by the second coldest, and the hottest August (1911) was followed the next year by the very coldest. This, however, is mere coincidence, but it is probably from such coincidences as these that popular beliefs regarding weather arise.

There appears to be no evidence whatsoever in support of the theory, "a hard winter, a warm summer." There seems to be no compensation of this type: some years are definitely warmer and some definitely colder than the average. The true averages of weather conditions are only arrived at over a long period of time, and there is no immediate compensation after a considerable variation from the normal. The climate of a place signifies more than simply the average weather, it must also include the extremes.

TABLE C.—EXTREMES OF SUNSHINE PER MONTH.

	Greatest.			Least.		
	Year.	Hours.	% of Average.	Year.	Hours.	% of Average.
Jan.	1923	60.4	137	1917	20.5	47
Feb.	1934	96.5	148	1923	23.6	35
Mar.	1929	163.2	159	1936	41.0	40
Apr.	1927	201.7	143	1920	101.8	72
May	1935	227.2	134	1924	111.4	65
June	1925	276.2	138	1935	128.2	65
July	1919	263.5	151	1936	120.8	71
Aug.	1935	219.3	144	1924	92.5	61
Sept.	1919	161.2	126	1936	80.1	63
Oct.	1931	121.4	135	1920	51.9	58
Nov.	1922	80.5	146	1920	32.9	60
Dec.	1926	53.6	154	1934	12.3	35

There is a record of sunshine figures for Perth for about twenty years only, and therefore no comparison with the earlier period can be made, and the averages are probably subject to considerable adjustment.

As can be seen from the tables of total hours of sunshine and of the percentage possible sunshine, the least sunny month both as regards actual amount and as regards the percentage of the possible is December, and June is the sunniest.

Of the seasons, summer naturally leads in the total hours of sunshine, and it also shows a slight percentage excess over spring. Autumn and winter are far behind.

The month which has shown the greatest percentage excess over the average is March, which in 1929 had a duration of sunshine 59% above the normal for the month, while at the other extreme the sunniest September (1919) was only 26% over normal. As regards deficiency of sun, there have been cases where the sunshine recorded was only 35% of the normal. Such very great percentage deficiencies occur only in the winter months, a fact which can be more readily understood when one remembers how small is the amount of total possible sunshine in winter compared to summer: a few hours' deficiency in winter will have a greater effect on the percentage than the same number of hours of deficiency in a summer month. No June has had less than 71% of the normal amount, and no April less than 72%: these are therefore the most dependable months for sun; August is the least dependable of the summer months.

There does not appear always to be very much direct connexion between the amount of sun and the temperature of a month. The least sunny February, November and December were among the mildest months known. On the other hand the sunniest January was an exceptionally warm one, and the same holds good of March, June and August, while May, 1935, which had such a wintry spell in it, snow falling in the middle of the month in many parts of the

GRAPHS OF MONTHLY WEATHER CONDITIONS FOR PERTH.

1883-1936.

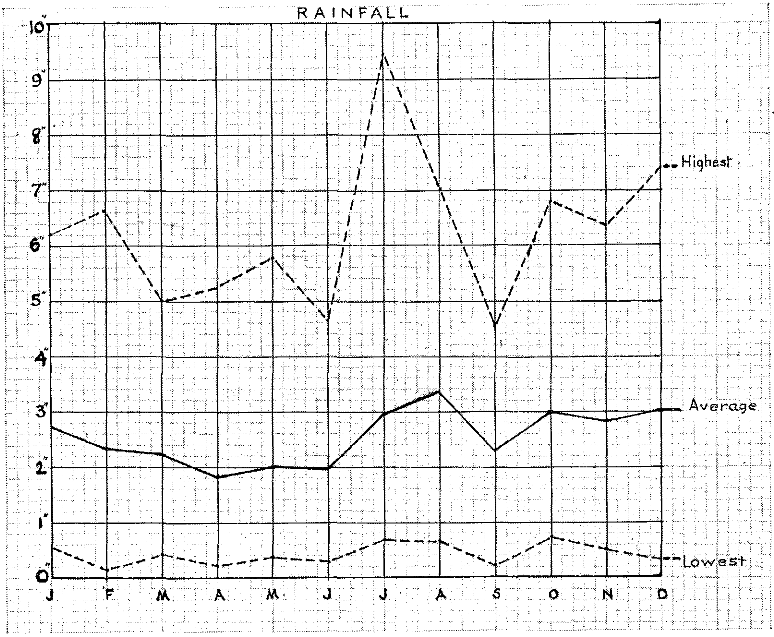


Plate XLII.

country though not in Perth, was the sunniest May on record: this was the famous "Jubilee" weather.

In winter, as mentioned before, comparatively little warmth comes directly from the sun, but rather indirectly by means of winds blowing from warmer latitudes. An excess of sun in the winter is not very likely to give conditions warmer than the average, indeed there is often much frost accompanying the sunshine, but much sunshine in summer has usually a more marked effect on temperature.

TABLE D.—RAINFALL: MONTHLY EXTREMES AND DAYS OF RAIN.

	Wettest.					Driest.				
	Year.	Ins.	% of Average.	Most Days of Rain. Yr.	Most Days of Rain. Rain.	Year.	Ins.	% of Average.	Fewest Days of Rain. Yr.	Fewest Days of Rain. Rain.
Jan.	1928	6.25	231.5	1928	28	1911	.49	18.1	1892, 1895, 1902, 1905	8
Feb.	1894	6.62	287.8	1926	25	1932	.16	7.0	1921	2
Mar.	1913	5.04	222.0	1928	26	1898	.47	20.7	1900	4
Apr.	1889	5.24	291.1	1934	22	1912	.22	12.2	1921	3
May	1924	5.78	286.1	1925	23	1936	.36	17.8	1896, 1935	6
June	1907, 1910	4.66	240.2	1912	22	1925	.29	14.9	1920	4
July	1916	9.44	324.4	1931	27	1913	.70	24.1	1913	4
Aug.	1895	7.07	212.3	1895	26	1933	.64	19.2	1899	5
Sept.	1930	4.53	198.7	1885	26	1894	.22	9.7	1894	3
Oct.	1916	6.81	223.3	1886, 1932	26	1919	.70	22.2	1919	5
Nov.	1888	6.39	226.6	1931	26	1934	.49	17.3	1901, 1922	5
Dec.	1914	7.38	240.4	1934	28	1926	.31	10.1	1892	8

A discovery which is made afresh very frequently and with not a little surprise is that August is Perth's wettest month. It is true, however, that it is only a little wetter than October and December, and it seems that of more recent years the rainfall of October is approaching very nearly to that of August. In the two periods under review the total annual rainfall remains almost exactly the same, though the distribution of rain throughout the year shows rather striking differences. Broadly speaking, we may say that in the past twenty-five years or so the winter rainfall has been greater than before and the summer rainfall less. The total number of days on which rain was recorded shows an increase, but that is probably due to different methods of recording.

February, though not on the average a very dry month, seems to be the month which on occasion is drier than any other: the very driest was February, 1932, with 0.16 in., and in February, 1891, there was 0.17 in. Incidentally February, 1932, showed the highest average barometric pressure for any month (30.524 ins.): usually the connexion between barometric pressure and rainfall is not so close, in most months there seems in fact to be no connexion at all.

At the other extreme from these dry Februaries comes that memorable month for rain, July, 1916, with 9.44 ins., 2 ins. heavier than the next wettest month, December, 1914. The heaviest day's rain was also recorded in July, 1916; on the 7th, 3.42 ins. of rain fell, a figure which, though great, is not very remarkable when compared to many other parts of the country: amounts up to 10 ins. have been recorded on occasion in twenty-four hours, and 5 or 6 ins. are not uncommon. It is in fact rather a remarkable feature of Perth's weather that very heavy falls of rain or of snow are most unusual: the position of the town has probably much to do with this.

There has never been so far a September with a recorded rainfall of more than 4:53 ins., a good support of the claims made for it as the most settled holiday month. June, too, has never been extremely wet, 4.66 ins. being the wettest. The heaviest September rainfall (4.53 ins.) is not as great as the average September rainfall for places like Greenock, rather a striking example of the dryness of the East compared to the West.

No month has ever been wet every day, though November, 1928, and November, 1934, had only three dry days each, while February, 1921, had only two wet days, and April of the same year, and September, 1895, had only three days when rain was recorded.

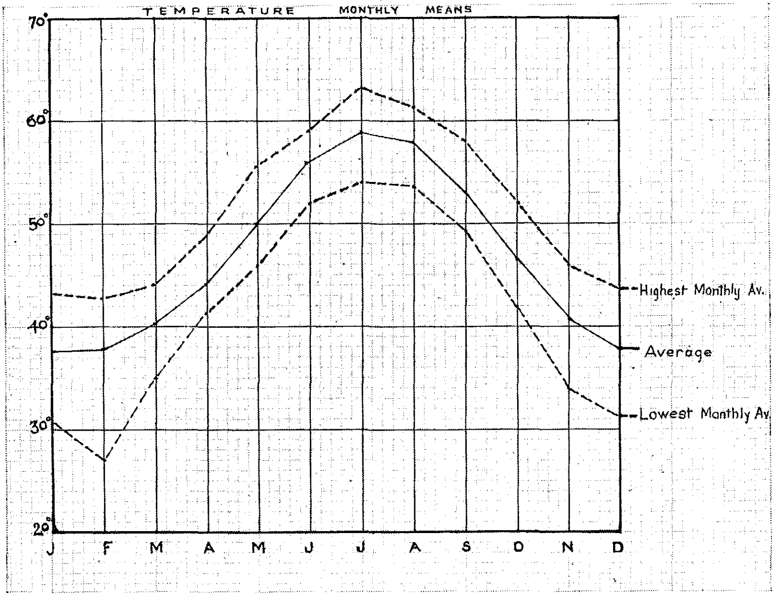
1916 was very wet in months other than the notorious July, and the total rainfall for the year, 47.4 ins., has never been closely approached in the past half-century except in 1903, when 43 ins. of rain fell. 1911, when the rainfall just exceeded 20 ins., was the driest year, and 1933 was little wetter.

It is impossible to make out any regular sequence of wet or dry years or of wet or dry seasons. There is no record of any year showing either excess or deficiency in rainfall for every one of the months, nor have there been many successive years when the rainfall of any particular month was consistently above or below average. Six years seems the longest continuous spell, though out of eighteen consecutive Septembers from 1905 to 1922 only three had a rainfall up to the average.

The main conclusions, therefore, that can be made from a comparison of the different sets of figures are perhaps of a rather negative nature.

Rainfall shows very little variation in the yearly average, with a slight increase of winter rain in more recent years, counterbalanced by a decrease in summer. True averages, both monthly and annual, have probably been arrived at, though the limit of the variations is probably not nearly reached yet.

The temperature, as mentioned previously, may have been affected by changes in the location of the weather recording station, and seems to show a considerable and almost general increase throughout the year in the second period. But excepting this, there is little real basis for any contention that the weather as a whole has shown any great material change during the period under review. Probably because of the comparative shortness of the whole period, it is difficult to discern any very constant weather cycles, though these cycles seem to exist in at least a general way.


TEMPERATURE MONTHLY MEANS
70°
60°
50°
40°
30°
20°
J F M A M J J A S O N D
Highest Monthly Av.
Average
Lowest Monthly Av.

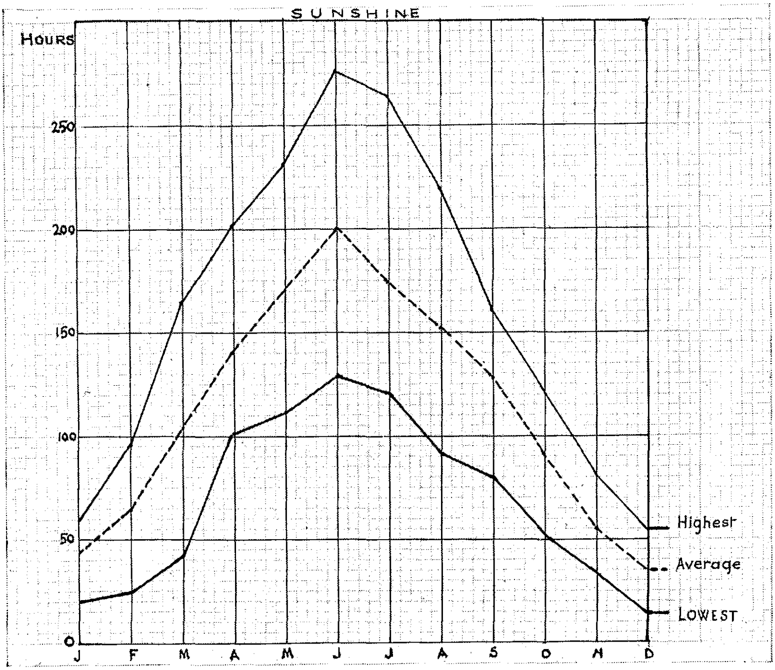

SUNSHINE
HOURS
250
200
150
100
50
0
J F M A M J J A S O N D
Highest
Average
LOWEST

Plate XLIII.

JANUARY.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.937	51	43.4	25	33.4	38.4	18	2.64	...
1910	29.626	54	41.8	−3	29.1	35.5	15	2.92	...
1911	30.183	53	44.3	25	35.1	39.7	13	.49	...
1912	29.896	54	41.0	15	31.4	36.2	12	2.88	...
1913	29.660	53	40.6	15	32.0	36.3	18	5.04	...
1914	30.010	55	43.0	19	33.7	38.4	14	2.07	...
1915	29.480	51	41.3	23	31.3	36.3	14	2.22	...
1916	29.803	54	49.1	27	37.1	43.1	18	3.65	...
1917	29.957	53	39.0	22	31.5	35.5	15	1.30	20.5
1918	29.772	52	40.8	1	29.1	35.0	19	50.1*	40.5
1919	29.624	46	40.6	16	30.9	35.8	19	66.6	27.4
1920	29.609	54	42.9	22	32.8	37.9	17	87.5	54.9
1921	29.684	55	46.4	23	34.8	40.6	18	96.9	44.2
1922	29.696	57	39.9	18	31.6	35.8	13	103.5	34.0
1923	29.904	54	48.6	24	36.3	42.5	14	49.4	60.4
1924	29.776	55	43.5	16	32.5	38.0	11	73.2	34.9
1925	29.952	54	45.2	28	35.5	40.3	17	74.1	35.7
1926	29.643	55	43.4	22	33.8	38.6	26	127.0	26.8
1927	29.490	57	43.6	16	33.4	38.5	21	72.4	46.5
1928	29.542	54	45.0	18	33.8	39.4	28	158.7	50.5
1929	30.261	52	38.7	16	27.3	33.0	15	24.7	35.7
1930	29.473	54	43.8	21	32.9	38.3	23	59.3	45.3
1931	29.710	52	41.7	16	29.8	35.7	12	63.6	61.6
1932	29.866	57	49.2	24	35.5	42.3	18	68.7	58.9
1933	29.998	53	39.0	15	27.5	33.7	13	39.4	40.4
1934	29.805	54	47.0	24	34.7	40.9	22	70.5	47.2
1935	30.117	57	45.8	26	33.6	39.7	12	23.4	55.6
1936	29.435	50	40.2	11	30.3	35.3	17	112.2	42.7

FEBRUARY.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	30.102	56	43.8	23	31.4	37.6	8	.87	...
1910	29.379	52	44.4	18	32.5	38.5	21	2.22	...
1911	29.980	56	49.5	17	31.6	38.8	15	2.03	...
1912	29.572	54	43.8	10	32.7	38.3	16	2.55	...
1913	30.054	51	45.0	27	33.0	39.0	13	.95	...
1914	29.423	55	48.4	25	37.1	42.8	21	3.62	...
1915	29.456	53	42.1	23	32.5	37.3	18	5.19	...
1916	29.647	50	42.3	22	31.9	37.1	19	4.25	...
1917	30.104	51	41.8	12	29.2	35.5	7	.70	72.1
1918	29.896	60	46.7	27	37.2	42.0	24	67.9*	52.2
1919	29.800	46	38.9	16	27.3	33.1	11	37.7	45.7
1920	29.938	55	48.6	28	35.6	42.1	15	74.5	88.0
1921	30.229	58	46.7	24	33.9	40.3	2	8.1	64.0
1922	29.653	56	43.1	22	32.9	38.0	16	72.1	55.0
1923	29.904	54	48.6	29	36.3	42.5	19	113.2	23.6
1924	29.976	54	45.1	27	35.0	40.1	6	21.8	63.6
1925	29.399	54	44.1	23	33.9	39.0	20	80.0	58.6
1926	29.695	57	45.9	23	36.5	41.2	25	122.2	50.1
1927	29.933	55	45.5	20	32.5	39.0	16	33.4	51.0
1928	29.805	56	45.9	26	34.4	40.1	18	57.8	78.5
1929	30.021	52	38.0	11	27.1	32.5	10	37.5	56.6
1930	30.171	53	40.7	17	26.7	33.7	10	31.9	75.1
1931	29.685	55	43.1	25	31.4	37.3	17	50.6	67.3
1932	30.524	58	46.9	21	30.8	38.9	7	4.1	94.4
1933	29.869	55	44.8	25	33.0	38.9	14	94.4	93.6
1934	30.288	56	48.9	24	34.5	41.7	3	5.4	96.5
1935	30.187	56	46.1	18	33.9	40.0	17	48.6	70.3
1936	29.727	49	40.2	16	29.0	34.6	15	79.2	48.7

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

MARCH.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.579	52	42.5	19	31.7	37.1	17	3.87	...
1910	30.048	59	50.9	27	35.9	43.4	9	1.49	...
1911	29.980	55	46.4	28	35.3	40.9	13	.87	...
1912	29.501	60	50.2	26	36.8	43.5	21	2.62	...
1913	29.605	56	47.8	25	34.6	41.2	22	5.04	...
1914	29.462	58	48.1	20	33.9	41.0	23	3.89	...
1915	29.947	61	47.6	19	32.1	39.9	11	1.25	...
1916	29.760	55	41.6	26	32.3	37.0	15	3.12	...
1917	29.795	55	43.7	5	29.1	36.4	20	2.73	118.3
1918	30.002	65	46.0	26	35.3	40.7	18	25.2*	68.5
1919	29.759	51	42.7	19	28.9	35.8	8	56.4	110.3
1920	29.711	59	48.4	26	37.1	42.8	15	52.4	97.2
1921	29.752	59	48.8	19	36.7	42.8	14	65.6	97.7
1922	29.830	58	47.3	25	34.5	40.9	11	49.7	103.8
1923	30.029	61	49.5	27	36.8	43.2	10	25.1	90.2
1924	29.833	51	44.6	18	29.4	37.0	5	19.0	108.7
1925	30.081	58	47.9	25	34.6	41.3	9	36.2	120.0
1926	29.904	59	48.7	30	37.4	43.1	17	37.9	86.1
1927	29.579	61	50.9	29	37.0	43.9	18	60.6	101.6
1928	29.772	53	45.5	23	36.0	40.7	26	115.0	47.6
1929	30.249	68	54.1	20	32.7	43.4	7	15.4	163.2
1930	29.733	55	45.9	24	33.4	39.7	18	41.9	117.1
1931	29.981	63	44.5	17	31.0	37.7	9	30.2	117.4
1932	29.875	59	47.8	23	34.3	41.1	13	64.2	107.8
1933	29.795	62	51.5	28	33.4	42.5	14	33.8	138.5
1934	29.589	64	47.1	22	31.5	39.3	20	85.9	118.2
1935	30.113	61	49.6	28	36.7	43.1	15	29.5	102.6
1936	29.799	60	47.9	25	36.8	42.3	14	49.7	41.0

APRIL.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.881	69	54.5	25	35.6	45.1	16	3.16	...
1910	29.745	61	54.1	27	36.0	43.6	17	3.83	...
1911	29.927	64	53.7	21	37.4	45.6	13	.90	...
1912	30.104	71	58.3	25	37.1	47.7	5	.22	...
1913	29.787	65	54.1	27	36.2	45.2	15	2.22	...
1914	29.938	75	59.9	29	37.2	48.6	10	.80	...
1915	29.937	68	54.2	28	36.8	45.5	14	1.17	...
1916	29.776	63	52.9	28	37.2	45.1	14	1.65	...
1917	29.822	63	48.7	19	33.6	41.2	13	1.49	131.3
1918	30.026	65	52.0	25	33.8	42.9	13	24.5*	178.0
1919	29.857	65	52.8	27	37.3	45.1	10	53.6	138.1
1920	29.638	59	51.0	27	37.7	44.4	14	50.6	101.8
1921	30.110	73	55.5	27	36.6	46.1	3	22.4	184.4
1922	29.736	58	50.1	23	32.1	41.1	12	56.5	152.1
1923	29.774	57	49.1	28	37.4	43.3	11	77.3	105.6
1924	29.783	67	52.3	25	36.2	44.3	8	37.0	150.2
1925	29.719	60	51.4	27	36.4	43.9	17	68.5	160.0
1926	29.797	67	55.4	28	39.0	47.2	18	44.8	137.2
1927	29.780	60	53.0	25	37.0	45.0	13	23.4	201.7
1928	29.776	64	52.8	28	38.8	45.8	14	16.6	130.1
1929	29.974	59	50.8	28	35.7	43.3	11	22.2	124.8
1930	29.830	62	53.0	27	39.4	46.2	14	32.8	138.5
1931	29.824	63	53.2	29	37.0	45.1	17	54.8	132.2
1932	29.648	59	50.8	27	33.8	42.3	20	71.8	136.7
1933	30.000	63	55.9	28	40.9	48.4	10	20.3	109.2
1934	29.745	62	51.4	28	36.4	43.9	22	115.2	121.9
1935	29.746	62	52.3	26	37.7	45.0	18	86.3	131.4
1936	30.013	63	51.8	22	33.5	42.7	6	14.0	156.9

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

MAY.

	Bar.	Temp.						Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.		Days.	Amt.	Hrs.
1909	30.069	75	60.0	29	40.3	50.2		13	3.10	...
1910	29.875	74	60.3	29	42.1	51.2		12	1.08	...
1911	29.975	75	65.0	32	43.1	54.1		9	.92	...
1912	29.929	69	61.2	31	41.8	51.5		9	1.29	...
1913	29.852	71	58.2	33	42.5	50.3		14	2.75	...
1914	30.016	72	59.3	31	41.7	50.5		15	1.56	...
1915	30.102	75	57.9	26	37.4	47.7		9	1.38	...
1916	29.876	75	57.2	35	41.4	49.3		18	3.93	...
1917	30.027	74	57.7	28	40.9	49.3		15	2.15	134.2
1918	30.014	73	61.5	30	45.2	53.4		17	81.1*	143.8
1919	30.040	80	61.0	30	42.3	51.7		7	29.3	193.3
1920	20.866	71	59.3	30	43.0	51.2		11	74.4	189.5
1921	29.834	75	59.7	27	41.7	50.7		14	39.9	208.5
1922	29.939	78	60.3	33	43.4	51.9		12	29.7	217.3
1923	29.826	64	55.5	31	39.4	47.5		8	19.6	183.5
1924	29.776	64	55.5	34	41.9	48.7		21	146.7	111.4
1925	29.686	64	57.8	32	44.9	51.3		23	97.8	130.4
1926	29.830	70	57.1	31	40.2	48.7		21	52.2	182.2
1927	30.048	74	57.6	28	40.4	49.0		14	49.5	165.3
1928	29.997	68	58.9	30	41.6	50.3		12	41.5	163.9
1929	29.898	74	59.9	25	42.1	51.0		15	59.6	164.3
1930	29.920	72	59.5	30	42.7	51.1		14	28.9	188.7
1931	29.783	72	59.6	29	43.4	51.5		17	81.3	174.8
1932	29.861	68	58.2	28	40.7	49.5		17	69.5	131.6
1933	29.943	73	58.5	29	43.6	51.1		18	36.1	115.3
1934	29.963	70	59.2	31	41.4	50.3		13	41.0	189.0
1935	30.223	69	59.1	26	38.9	49.0		6	11.2	227.2
1936	30.128	71	61.0	34	42.5	51.7		8	9.2	181.4

JUNE.

	Bar.	Temp.						Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.		Days.	Amt.	Hrs.
1909	29.999	72	64.5	37	44.6	54.6		11	1.13	...
1910	29.891	79	66.5	35	45.4	56.0		17	4.66	...
1911	29.935	80	66.3	32	45.3	55.8		8	1.56	...
1912	29.748	72	62.5	36	48.5	55.5		25	3.14	...
1913	29.960	77	65.8	38	47.7	56.8		15	2.02	...
1914	30.031	83	68.8	35	47.0	57.9		9	.37	...
1915	30.029	79	66.7	34	45.3	56.0		5	1.84	...
1916	29.835	71	61.7	34	45.4	53.6		13	2.11	...
1917	29.958	70	63.5	36	46.8	55.2		10	1.86	202.6
1918	29.982	78	64.8	30	45.7	55.3		6	8.5*	205.1
1919	29.992	75	65.5	34	46.4	56.0		12	29.0	203.7
1920	29.983	75	65.0	36	46.5	55.8		8	24.7	219.2
1921	30.150	83	67.7	36	46.6	57.2		4	13.4	236.0
1922	29.876	81	63.5	38	46.4	55.0		12	60.4	199.7
1923	30.019	80	64.5	36	46.4	55.5		8	18.1	182.4
1924	29.902	71	63.0	37	47.5	55.3		10	58.1	183.6
1925	30.078	86	69.1	44	48.7	58.9		5	7.4	276.2
1926	29.844	73	65.2	38	47.7	56.5		18	73.9	186.0
1927	29.742	66	60.5	35	43.9	52.2		16	72.4	178.7
1928	29.776	75	60.2	31	43.9	52.1		20	93.5	196.0
1929	29.876	75	64.5	35	46.0	55.3		14	36.5	212.9
1930	29.907	76	67.3	41	49.9	58.6		10	47.7	235.1
1931	29.910	71	61.2	38	48.0	54.6		18	113.8	135.2
1932	30.040	79	66.4	36	45.5	55.9		6	27.3	198.4
1933	29.856	81	70.2	37	47.8	59.0		13	28.0	233.9
1934	30.049	76	67.4	35	47.1	57.3		11	39.0	194.6
1935	29.800	78	63.2	39	49.5	56.3		21	69.5	128.2
1936	29.987	81	68.0	31	45.6	56.8		9	45.4	205.1

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

JULY.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.776	74	66.5	37	48.9	57.7	16	3.39	...
1910	29.836	79	65.7	40	48.8	57.3	17	4.66	...
1911	30.085	90	71.9	36	50.8	61.4	14	1.63	...
1912	29.927	79	68.0	42	50.6	59.3	8	1.99	...
1913	30.052	78	69.4	38	50.4	59.9	4	.70	...
1914	29.810	83	68.7	40	50.9	59.8	11	2.83	...
1915	29.768	73	66.7	39	48.8	57.8	19	2.45	...
1916	29.950	79	67.4	42	50.6	59.0	12	9.44	...
1917	30.038	78	68.5	39	48.9	58.7	8	1.18	197.2
1918	29.818	78	64.4	35	49.6	59.0	18	118.6*	196.7
1919	30.016	76	68.6	38	46.7	57.7	5	18.1	263.5
1920	29.767	67	63.1	37	49.0	56.1	17	57.5	139.4
1921	29.969	86	69.6	39	52.7	61.2	12	66.8	191.6
1922	29.753	70	63.2	40	47.9	55.6	13	37.4	141.4
1923	29.859	80	68.1	47	53.2	60.7	13	57.4	170.9
1924	29.744	75	65.3	42	50.9	58.1	21	128.5	153.3
1925	29.893	83	70.7	43	52.4	61.5	10	42.9	182.1
1926	29.968	84	70.3	40	52.3	61.3	11	65.6	200.0
1927	29.843	78	68.6	43	52.6	60.6	21	88.9	153.4
1928	29.893	73	66.0	41	50.2	58.1	15	21.1	182.1
1929	29.913	78	67.3	41	50.7	59.0	14	90.0	167.8
1930	29.755	77	66.9	46	52.7	59.8	18	70.4	141.5
1931	29.654	79	65.6	45	52.2	58.9	27	100.7	98.4
1932	29.759	77	66.5	42	51.7	59.1	18	64.5	148.3
1933	29.912	87	71.6	45	53.4	62.5	17	69.1	167.1
1934	29.912	88	73.0	46	52.5	62.7	15	95.7	216.9
1935	30.043	82	70.3	39	49.8	59.9	8	18.9	229.7
1936	29.707	74	67.7	40	51.5	59.6	21	111.4	120.8

AUGUST.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.903	81	67.2	35	49.9	58.6	14	1.91	...
1910	29.771	75	66.1	44	51.9	59.2	23	6.80	...
1911	29.945	81	71.1	41	51.7	61.4	13	1.31	...
1912	29.664	68	61.2	34	46.2	53.7	19	3.82	...
1913	30.021	80	69.0	37	48.1	58.6	9	.83	...
1914	29.931	81	67.0	43	48.9	58.0	17	2.05	...
1915	29.951	73	66.9	35	49.9	58.4	18	4.80	...
1916	29.860	83	67.8	33	49.7	58.8	8	2.98	144.9
1917	29.594	76	66.8	42	52.1	59.5	19	5.67	112.8
1918	29.865	74	66.0	44	52.3	59.2	15	90.7*	119.9
1919	29.852	77	67.4	36	49.2	58.3	10	57.4	210.3
1920	30.007	74	63.3	38	48.8	56.1	14	86.7	143.3
1921	29.823	75	63.5	33	50.4	57.0	21	128.1	124.2
1922	29.831	68	63.1	38	48.1	55.6	13	37.4	141.4
1923	29.714	74	64.7	39	49.3	57.0	11	115.7	166.5
1924	29.671	70	63.0	39	49.4	56.2	16	90.1	92.5
1925	29.877	77	67.7	41	50.8	59.3	14	50.5	149.1
1926	29.914	78	68.9	43	51.1	60.0	16	45.2	192.1
1927	29.672	73	66.2	41	51.9	59.1	24	136.1	136.2
1928	29.805	79	65.8	40	49.8	57.8	20	91.7	128.0
1929	29.823	70	64.3	42	49.7	57.0	23	76.7	139.4
1930	29.733	80	66.3	40	52.6	59.5	22	102.7	162.0
1931	29.916	77	64.5	36	47.4	55.9	14	61.2	152.9
1932	30.041	78	67.7	33	50.6	59.1	10	25.1	146.3
1933	29.896	83	69.5	42	51.9	60.7	13	16.4	198.8
1934	29.748	71	65.5	35	49.4	57.5	17	85.1	149.6
1935	29.940	80	69.3	40	52.1	60.7	12	56.4	219.3
1936	30.009	78	68.9	...	...	...	10	40.8	163.6

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

SEPTEMBER.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	30.045	71	59.6	31	42.2	50.9	13	1.49	...
1910	30.207	73	64.0	37	45.5	54.8	9	.76	...
1911	29.974	71	62.9	28	43.0	53.0	8	1.05	...
1912	30.157	73	59.7	33	42.9	51.3	7	2.19	...
1913	29.997	70	61.8	35	46.6	54.2	10	1.84	...
1914	29.971	74	61.8	28	45.6	53.7	8	.63	...
1915	29.979	74	61.6	36	45.2	53.4	10	1.86	...
1916	30.003	72	61.6	32	44.9	53.3	9	1.40	123.0
1917	29.843	71	62.6	35	46.4	54.5	18	1.11	109.4
1918	29.554	68	57.8	31	41.0	49.4	17	98.6*	126.1
1919	29.853	70	61.0	28	44.6	52.8	8	25.7	161.2
1920	29.925	67	60.6	31	45.5	53.1	12	32.2	99.4
1921	30.017	73	62.2	39	48.1	55.2	6	37.4	139.7
1922	29.913	68	60.1	28	43.6	51.9	14	33.5	109.7
1923	29.748	68	60.1	33	45.2	52.7	12	77.6	146.1
1924	29.657	70	60.8	30	46.2	53.5	15	92.4	146.1
1925	29.831	66	58.9	30	43.7	51.3	19	82.4	133.8
1926	29.947	77	62.7	30	45.9	54.3	18	81.5	136.8
1927	29.695	69	59.4	34	44.1	51.7	23	106.9	102.2
1928	30.050	70	61.8	25	42.3	52.1	14	72.1	150.9
1929	29.956	74	64.5	34	48.6	56.5	7	10.2	149.4
1930	29.897	71	61.3	33	48.4	54.9	15	115.1	91.5
1931	30.147	70	60.9	29	42.7	51.8	11	32.3	139.0
1932	29.734	71	60.5	29	45.2	52.9	17	45.2	129.5
1933	30.108	73	66.4	38	46.5	56.5	8	30.1	146.4
1934	29.794	69	62.8	35	46.6	54.7	22	79.5	133.2
1935	29.683	66	60.7	33	45.6	53.1	18	114.0	128.8
1936	29.990	71	63.6	...	...	...	14	84.8	80.1

OCTOBER.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.627	63	53.8	19	40.0	46.9	20	4.28	...
1910	30.057	70	56.4	32	42.0	49.2	13	2.26	...
1911	29.929	59	52.8	19	36.5	44.7	14	1.92	...
1912	29.807	67	53.2	28	37.6	45.4	15	3.24	...
1913	29.797	65	56.8	30	43.4	50.0	19	1.53	...
1914	30.003	66	56.8	30	41.2	49.0	14	2.38	...
1915	30.052	61	52.9	26	38.2	45.6	15	2.54	...
1916	29.631	64	54.0	21	37.9	47.0	23	6.81	72.2
1917	29.526	60	50.4	22	35.9	43.2	24	2.77	97.8
1918	29.806	62	54.5	30	41.6	48.1	20	89.0*	68.9
1919	30.134	64	53.3	29	38.5	45.9	5	17.7	95.9
1920	29.971	64	54.4	30	42.3	48.4	9	49.5	51.9
1921	30.025	73	58.6	27	45.5	52.1	16	80.5	75.0
1922	30.119	65	53.3	20	37.1	45.2	8	57.1	89.0
1923	29.434	60	54.2	30	42.3	48.3	16	68.6	112.7
1924	29.784	62	54.1	29	40.4	47.3	17	92.0	85.7
1925	29.776	72	56.0	22	41.9	48.9	17	60.4	97.6
1926	29.837	77	50.9	23	35.5	43.2	18	118.8	117.7
1927	29.889	70	56.4	22	41.1	48.7	19	122.8	106.4
1928	29.660	64	55.0	25	39.1	47.1	22	94.8	84.7
1929	29.582	64	53.6	24	40.2	46.9	19	91.6	113.8
1930	29.620	62	55.4	28	43.4	49.4	24	70.1	103.6
1931	30.001	65	54.4	24	39.7	47.1	16	21.1	121.4
1932	29.576	59	51.3	27	38.1	44.7	26	151.5	78.9
1933	29.848	68	55.5	34	42.5	49.0	15	83.5	78.0
1934	29.712	65	55.0	27	41.1	48.1	18	77.1	98.4
1935	29.624	60	52.5	28	40.0	46.3	23	127.7	57.0
1936	29.999	63	56.0	27	40.7	48.3	12	57.0	86.5

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

NOVEMBER.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.941	59	46.3	11	28.5	37.4	8	.53	...
1910	29.585	48	41.9	17	29.3	35.6	11	3.26	...
1911	29.599	54	46.3	25	34.6	40.5	23	3.75	...
1912	29.836	57	47.7	12	35.2	41.5	10	2.05	...
1913	29.626	55	50.5	26	38.9	44.7	17	2.27	...
1914	29.742	58	47.8	22	36.3	42.1	21	4.12	...
1915	29.919	54	41.5	15	28.2	34.9	6	1.92	...
1916	29.571	59	48.8	31	38.7	43.8	19	4.59	40.2
1917	29.846	60	50.1	27	38.1	44.1	20	2.99	57.4
1918	29.881	58	44.7	24	31.5	38.1	14	40.6*	45.4
1919	29.754	56	40.6	−7	27.5	34.1	15	129.6	66.9
1920	29.893	59	49.2	20	39.8	44.5	10	64.8	32.9
1921	30.033	56	44.7	22	33.1	38.9	12	51.6	60.2
1922	30.053	57	49.3	26	35.7	42.5	5	49.6	80.5
1923	29.627	55	43.0	19	31.7	37.4	10	58.6	75.1
1924	29.930	55	49.2	24	37.4	43.3	11	46.1	44.2
1925	29.938	54	42.1	20	28.2	35.1	6	14.8	68.7
1926	29.460	57	45.9	18	33.5	39.7	24	155.5	60.0
1927	29.861	62	46.9	21	35.7	41.3	18	60.3	62.3
1928	29.577	61	50.2	22	37.5	43.9	22	69.3	62.7
1929	29.522	56	48.1	19	35.1	41.6	24	81.7	56.3
1930	29.705	55	46.1	19	32.5	39.3	18	91.0	69.5
1931	29.581	58	48.7	30	38.4	43.5	26	135.2	37.6
1932	29.916	56	46.9	24	34.3	40.6	18	30.4	47.8
1933	29.937	64	46.2	24	33.9	40.1	18	55.2	43.8
1934	29.998	54	46.8	21	33.4	40.1	17	55.2	43.8
1935	29.570	56	46.2	26	35.9	41.1	23	111.7	37.1
1936	29.811	55	45.6	24	34.0	39.8	18	56.3	40.5

DECEMBER.

	Bar.	Temp.					Rain.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Amt.	Hrs.
1909	29.582	54	40.2	11	29.1	34.7	19	3.35	...
1910	29.575	55	46.8	22	37.2	42.0	22	2.62	...
1911	29.501	55	44.6	26	34.6	39.6	24	4.02	...
1912	29.570	56	45.9	16	34.1	40.0	25	4.11	...
1913	29.904	56	44.8	13	32.8	38.8	10	1.22	...
1914	29.404	52	42.1	16	30.4	36.3	19	7.38	...
1915	29.503	49	40.2	19	31.9	36.1	24	6.27	...
1916	29.536	50	41.2	21	30.8	36.0	18	3.70	31.0
1917	30.123	55	41.5	10	29.5	35.5	15	1.89	32.8
1918	29.610	56	45.1	20	33.6	39.4	18	40.5*	40.0
1919	29.551	51	43.4	17	31.8	37.6	19	98.5	45.4
1920	29.902	52	42.0	17	31.0	36.5	18	85.3	24.3
1921	29.804	59	49.1	24	36.3	42.7	14	73.9	38.4
1922	29.602	56	46.0	25	35.1	40.6	17	62.3	37.8
1923	29.802	54	42.6	12	30.0	36.3	9	55.7	38.1
1924	29.627	55	48.4	28	39.4	43.9	23	120.2	31.5
1925	29.591	51	40.0	7	25.8	32.9	9	86.1	45.6
1926	30.218	53	44.7	20	34.6	39.6	10	7.9	53.6
1927	29.959	49	38.3	15	30.7	34.5	13	42.6	17.9
1928	29.910	55	43.0	23	31.1	37.1	20	79.1	39.8
1929	29.387	55	45.1	23	35.7	40.4	25	103.4	52.3
1930	29.703	53	41.5	17	31.6	36.5	17	90.1	37.3
1931	30.058	56	47.2	28	37.4	42.3	16	32.0	24.6
1932	29.896	57	46.2	20	36.3	41.3	23	112.7	25.0
1933	30.135	50	41.6	24	32.5	37.1	20	26.5	18.9
1934	29.412	55	47.5	26	39.9	43.7	28	101.7	12.3
1935	29.560	46	39.7	12	26.9	33.3	11	57.1	43.8
1936	29.843	54	46.3	23	36.1	41.2	18	101.5	40.2

*Until 1917 rainfall amount is given in ins., after 1918 in mm.

ABSTRACT OF WEATHER STATISTICS.

1883—1908.

	Pressure.	Temperature.					Rainfall.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Ins.	Hours.
Jan.	29.859	59.0	42.5	−4.0	31.8	37.11	14	2.57	...
Feb.	29.879	60.0	43.4	0.0	31.2	37.27	12	2.19	...
Mar.	29.814	69.0	46.7	9.5	32.7	39.70	14	2.39	...
Apr.	29.884	71.2	52.5	8.5	35.8	44.24	11	1.78	...
May	29.932	81.0	58.3	25.0	40.6	49.49	13	2.00	...
June	29.982	85.0	64.8	30.0	46.6	55.67	11	1.99	...
July	29.904	88.0	66.9	36.5	49.4	58.17	15	2.95	...
Aug.	29.853	84.0	65.4	33.0	48.6	57.00	16	3.49	...
Sept.	29.917	83.0	61.5	27.0	45.2	53.33	14	2.37	...
Oct.	29.824	76.0	53.4	20.5	39.0	46.20	16	2.96	...
Nov.	29.853	62.5	47.3	12.0	35.6	41.47	16	2.87	...
Dec.	29.779	59.0	42.9	5.0	32.2	37.55	16	2.96	...
Year	29.874	88.0	...	−4.0	...	46.43	168	30.52	...

1909—1936.

	Pressure.	Temperature.					Rainfall.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Ins.	Hours.
Jan.	29.782	57.0	43.2	−3.0	32.5	37.92	17	2.83	44.2
Feb.	29.872	60.0	44.6	10.0	32.6	38.54	14	2.40	65.2
Mar.	29.822	68.0	47.4	5.0	34.1	40.78	15	2.15	102.8
Apr.	29.810	75.0	53.0	19.0	36.6	44.77	13	1.81	141.1
May	29.938	80.0	59.1	26.0	41.8	50.49	14	2.04	169.8
June	29.938	86.0	65.1	30.0	46.6	55.82	12	1.89	200.1
July	29.872	90.0	67.8	35.0	50.7	59.37	15	2.87	174.1
Aug.	29.849	83.0	66.6	33.0	50.1	58.22	16	3.17	152.1
Sept.	29.921	77.0	61.4	25.0	45.0	53.11	13	2.20	127.7
Oct.	29.807	77.0	54.3	19.0	40.9	47.29	17	3.14	90.1
Nov.	29.769	64.0	46.5	−7.0	34.2	40.34	16	2.77	55.1
Dec.	29.724	59.0	43.8	7.0	33.1	38.39	18	3.17	34.8
Year	29.842	90.0	...	−7.0	...	47.09	180	30.44	1357.1

1883—1936.

	Pressure.	Temperature.					Rainfall.		Sunshine.
	Ins.	Highest.	Mean Highest.	Lowest.	Mean Lowest.	Mean.	Days.	Ins.	Hours.
Jan.	29.820	59.0	42.9	−4.0	32.2	37.53	16	2.70	44.2
Feb.	29.876	60.0	44.0	0.0	31.9	37.92	13	2.30	65.2
Mar.	29.818	69.0	47.1	5.0	33.4	40.25	15	2.27	102.8
Apr.	29.846	75.0	52.8	8.5	36.2	44.51	12	1.80	141.1
May	29.941	81.0	58.7	25.0	41.2	50.01	14	2.02	169.8
June	29.915	86.0	65.0	30.0	46.6	55.75	12	1.94	200.1
July	29.888	90.0	67.4	35.0	50.1	58.79	15	2.91	174.1
Aug.	29.851	84.0	66.0	33.0	49.4	57.63	16	3.33	152.1
Sept.	29.919	83.0	61.4	25.0	45.1	53.22	13	2.28	127.7
Oct.	29.816	77.0	53.9	19.0	40.0	46.76	17	3.05	90.1
Nov.	29.810	64.0	46.9	−7.0	34.9	40.90	16	2.82	55.1
Dec.	29.751	59.0	43.4	5.0	32.7	37.98	17	3.07	34.8
Year	29.858	90.0	...	−7.0	...	46.77	176	30.49	1357.1

XLVII.—THE DIARY OF DR. JOHN LYELL, SHIP SURGEON, ON A VOYAGE TO THE SOUTHERN ARCTIC SEAS (1829-33).

By JOHN RITCHIE, F.R.A.I.

Dr. John Lyell, extracts of whose diary I am now going to submit to the P.S.N.S., was born in August, 1807. After qualifying, he joined the Whaler " The Ranger," under the Commander Captain Yarbutt. This vessel, formerly a sloop of the war 14 years previously had been refitted as a Whaler, and with Dr. Lyell as Medical Officer it left London on October 17th, 1829. Dr. Lyell, on returning from this voyage, settled in Newburgh, ministering to the sick and infirmed in Newburgh and Abernethy. While there, he interested himself greatly in the propagation of plants, and became the founder of the local Horticultural Association. He also, probably as a result of his early wanderings, introduced and grew new species of plants. I think he published a small book on Plant Life.

He continued his practice there until 1870, then went to Glasgow and became City Missionary. A short service in that City brought on ill health; he was forced to come back to Perth in 1874, and died five years later in Perth, leaving behind him a family of four. He was buried at Abdie in Newburgh, and the practice was taken over by his son, David.

A grandson was Dr. John Lyell, who carried on a practice here in Perth, and was an active member in our own Society.

The following is a resumé of the diary he kept written. The day after passing the Lizard " a considerable number of that hardy bird the Petrel was observed gleaning the sea for their scanty subsistence, and a land bird of the Thrush genus perched on the rigging in an exhausted state." On the 29th, while in Latitude 43° 1′ N. and Longitude 14° 10′ W., with an Air Temperature of 60° F. and the sea surface reading 63° F., a number of Cetaceous animals of the porpoise kind were observed frisking round our ship. By the 31st of October the shade temperature stood at 71° F., and on that day a land bird of the Wader tribe about the size of a partridge and somewhat similar plumage, lighted on the deck and was caught; its skin was preserved.

By 11th November to 18th November, the sloop between the Canary and the Cape Verde Islands, saw Flying Fish, Dolphins and Sperm Whales. The boats were lowered but, unfortunately, due to the inexperience of the crews, none were obtained. On Decmber 2nd, Brana was reached, and the next two days were spent in obtaining stores. On the way to the Governor's Office, plantations of maize, overgrown with casaba, pumpkins and creepers; few birds were seen, but lizards and grasshoppers sported about in myriads, while the beach abounded with a nimble grey crab.

The stores obtained were paid for in kind. For instance, one laıge pig procured for two shirts (valued in London at 2/4 each), a pig of 4-stone weight; 1 shirt, 3 small fowls, a 6d. knife; a small bullock for 8 shirts; a bunch of bananas for 1 handkerchief, etc. Leaving this and sailing south, no whales were seen, although the sea teemed with Flying Fish, until on the 27th November a Finner Whale was seen. Three days later the vessel saw a school of Blackfish (Physeter turso Ceto-dontida). Lowered a boat and succeeded in killing one, measuring 16 ft. long, 4 ft. dorso-ventral diameter and 2½ ft. lateral diameter, and the yield—2½ barrels of oil. In its dying agonies it attempted to lay hold on the boat with its teeth, and when towing in aboard its neighbours followed it in numbers about 40, and with ease many of them might have been killed, but they yielded not the kind of oil intended for our cargo, and we would not have captured this one unless the stock of oil for our lamps had been low. In the afternoon, a blue shark, attracted by the "Kreng" thrown overboard, was harpooned from the bow and hung up and mangled to death. December 6th saw the crossing of the Equator. Trinidad was descried on the 15th of December. This island, Dr. Lyell in his diary says: "Trinidad was formerly a place of exile for the Brazilian Portuguese but, for some cause unknown, is at present uninhabited; its general character is sterile and rocky, but some portions of it are capable of producing fruits and grain abundantly. Vessels sometimes send their boats on shore here to procure water and hogs, of the latter of which abundance run wild in the mountains and valleys." Christmas Day he makes no record of, but on a moonlight night of December 31st a porpoise was harpooned from the bow, and later afforded a mess of fresh steaks for all aboard.

Description of Harpooning.

I shall give a concise description of the means by which this is obtained, and first, as first in use, regarding the boats. The Ranger mans four boats, each of which is provided with 6 harpoons. The harpoon is formed out of the most ductile iron, the shank is coarsely polished, and the head ground and smoothed to as fine an edge as possible; it is technically termed an iron. If time is allowed after arriving within 11 feet or nearer of the whale, two harpoons are darted in, one of which is bent on to the line and bears all the strain, whilst the other has the line passing through a noose on the end of a short line, termed a presentine warp, connected with it, and only comes to bear strain when the first harpoon withdraws. A boat goes up to strike behind usually, but sometimes straight in front, in either case it avoids being seen by the whale.

Three lances having smooth iron shanks, steeled head, and sharp edges. After a whale is entangled with the harpoon 'tis with the lance its death is effected; the extreme distance at which a lance is darted may be stated at fathoms, and the usual stroke that proves fatal is between the ribs into the lungs. When darted the lance is drawn back again into the boat by means of a slender warp, termed a lance warp; the handles are made of tough heavy wood. 1 line tub containing from 180 to 200 fathoms of rope $\frac{3}{4}$-inch diameter, neatly coiled. This is distinguished from the other lines in the boat by the definite article "the line." 2 Crutches, stuck into the gunwale of the boat to support the handle of the harpoons and lances. 1 Drogue Waft. 1 Waft Drogue. A square body formed of cork strengthened by wood on its upper side, and covered with tarred canvas; a wooden shaft is secured into its middle at right angles, near one end, into which a hole is bored to receive the drogue waft, and to the lower is attached a mass of lead. Thus contrived, when left at rest in the water, it swims with the leaded end always lowermost and with the small flag flying in the air. When the line is otherwise employed, the harpoon is sometimes attached through the medium of a short line (Drogue warp) to the leaded extremity of this Drogue, and struck into a whale: as the whale swims, the flat head comes into opposition with the water and offers considerable impediment to its progress, and when it rises to the surface to take breath, the small flag points out the spot to which the boats are to pull to ply their lances. The buoyant part of this machine was formerly constructed hollow of wood or copper, but the great pressure to which it is subjected when the whale descends deep, was often found to crush its sides together.

Common Drogue, a machine constructed of wood similar to the preceding, but without the cork or waft; used also to impede a whale in its progress through the water.

2 Wafts. If more whales are seen when one is killed, it is left floating with a waft stuck into it to preserve it in sight whilst the others are pursued.

1 Water Keg containing fresh water for the crew.

1 Lanthorn Keg containing Lanthorn, a few wax candles, materials for striking light, and several blue lights, useful on the boats getting benighted.

1 Baling Piggin.

1 Bucket for watering the line when friction is great.

1 Spade.

1 Hatchet.

1 Knife.

3 Lance Warps, 7 fathoms each.

1 Drogue, 5 fathoms.

1 Preventive Warp, attached to the second harpoon.

1 Tow Rope for towing the dead whale.

1 Stopper. A piece of rope to fasten to one of the shafts, by turning which round the lines running out they may be stopped.

1 Boat Hook.

6 Oars.

1 Mast with Sail and sprit.

Trawls and a few other nick-nacks—

The operation of flensing (freeing the whale of its blubber), is thus performed. The whale, when towed alongside by a rope attached to its lower jaw, has the noose of a strong warp from the starboard bow of the vessel slipped over its head along its body to the rump where it is drawn tight just before the tail; the jaw or tow rope is taken abaft the main rigging and then tightened; half-way between the eye and the pectoral fin of the right side, a hole is made through the blubber with a spade into which a strong iron hook is inserted connected with a powerful pulley, worked by the windlass, by heaving which the blubber is put on the stretch, and the commencement of a strip 4 or 5 feet in breadth is freed from the body easily by a spade, toward the ship. This strip is continued spirally along the whole body till it terminates at the tail; in the removal of it, when the first or upper end has reached towards the top of the main shrouds, another tackle, similar to the former and worked also by the windlass, is made fast to the lower part just over the deck, and the portion above cut off and lowered into the main hold, using the precaution of placing it with the skin lowermost that as little oil as possible may escape. In this manner the one tackle is made to succeed the other till the whole blubber is got on board; the iron hook, however, is only used in heaving on board the first piece, an eye on the end of the tackle passed through a hole in the blubber and secured by a piece of wood (termed a foad), pushed through the eye on the opposite side is used for the remainder. Whilst the body is thus getting freed from the blubber, the large mass of blubber tendon and muscle on the head, containing the case with the spermaceti, is cut off, stowed on the quarter by a warp, until all the blubber has been got on board, or if there are more whales than one, till the blubber of the last has been got in off the body. It is then hoisted on board with one or both tackles according to the size. When on board, the blubber of any value is removed, the case cut into and the sperm baled out of it into the tank (a copper vessel capable of holding about 5 tons of oil, situated in the 'tween decks abaft the mainmast), and the tendinous and fleshy matter cast overboard.

The only implements used in flensing are spades with long handles, a boarding knife, a nd a few gaffs. The captain, chief, and second officers have their station on stages over the side, and free the blubber from the body. The carpenter with an assistant is employed grinding spades; two are employed arranging the blubber in the main hatchway or blubber room; several are engaged with the tackles on the main deck; and the remainder work the windlass. As a good deal of fatty matter sometimes escapes in severing the head piece from the body, this is collected from the surface of the water and got on board by means of two special instruments.

Scurvy.

About this time scurvy manifested itself among the crew. Dr. Lyell's observations are interesting, not only regarding this, but also the conditions under which the crews existed on such voyages. "The staple articles of provision since leaving England have been beef, pork, flour, peas, barley and rice. At Brana and Timon we had a moderate supply of fresh stock, but except the first few months at sea when the potatoes brought from Gravesend were issued out, there has been an almost total deficiency of fresh succulent vegetables. As a prevention we were furnished with a small quantity of sour krout, alias pickled cabbage, two 42 gallon casks of which have been used in the course of the voyage, and pickled potatoes were now served out to those of the crew in whom a scorbutic taint evidently prevailed. But the predisponent cause lay much less, I conceive, in the diet, than the impurity of air, and fits of excessive exertion to which the crew were subjected. When whales were pursued in a hot sun, and every chance of success lay in the oar, one might easily conceive every effort would be used to ensure the possession of a prize on which depended their pay: and indeed, so much was this the case that some of the seamen might constantly be seen with their backs covered with erysipelatous blisters induced by the exposure of their naked bodies to the direct rays of the burning sun. In the worst cases, I have seen the whole shoulders and back as far as the loins covered with blisters, some of which were as large as the hand; and in others, the cuticle being abraded, left the unprotected, inflamed skin torturingly alive to the slightest touch. So much would they suffer to be unembarrassed in the execution of their movements; and if their exertions proved effectual in the capture of the desired object, the subsequent duties required, ere this could be converted into pure oil and safely deposited in the hold, were extremely fatiguing. In attending to the try pots, they were broiled before a blazing fire and scorched under an almost vertical sun; and perhaps the next moment drenched in a torrent of rain. In stowing away in the hold they had to breathe an air highly contaminated by hydrothionic acid and other gases. But an insidious enemy that made a constant inroad on their constitutions was the aerial impurity of the interior of the ship. This was partly unavoidable owing to the nature of the voyage. The dampness of the air was kept up even in the dryest weather by the necessary practice of watering the casks in the hold to keep them from shrinking and leaking the oil; and it often was surcharged with noxious effluvia, arising from putrid blubber. In the half deck, where a third part of the crew slept, a filthy mixture of blood, water and oil sometimes stood several inches deep, which could not but impart a deleterious character to the incumbent air; this the offensive smell evidently at once pointed out. Now, there being no side ports for the seamen's berths, there was a consequent imperfect ventilation, and the unhealthy air was allowed to exercise all its virulence, with but a partial escape through the hatches. Taking all these things into consideration, it is rather to be wondered at that the scorbutic ravages were so slight."

Fishing.

In August, 1831, while on the look-out for "the fellows that smoked their pipes," we saw numerous porpoises, grampus, black-fish, etc., also a most curious whale, which the sailors termed the shovel nosed whale. The end of September saw the whaler move south, touching at Gypan, Tinian and Asotto, where fresh food was obtained from the natives. The boat proceeded to Guam, and at Umattae loaded up with 200 barrels of fresh water. The author of the diary saw a curious method adopted at this place by the natives for catching fish, as follows:—"I may here take notice of a curious method for catching fish employed at these islands and, so far as I know, never before described. One fish is caught by any of the usual methods, put into a pool communicating with the sea, and attended with great care, being fed daily with mashed cocoanuts. A hole is cut in the side of the mouth to which a cord is attached, and when the canoes leave the shore it generally accompanies them; in this manner it becomes tame. When the native, its master, if I may be granted the expression, goes afishing in his canoe, the tame fish swims alongside restrained by a bit of cord. After he has gained the proper fishing station, he takes a sacciform hoop net and, making the tame fish fast to its margin, sinks it to a convenient depth. The tame fish immediately when let down begins fluttering in the bottom of the net, and attracts others of a like species (if any in the neighbourhood), by its manœuvres. From the cord attached to the tame fish, or some other cause, the others immediately begin fighting with it, and while earnestly engaged in the combat (which the man easily perceives by the clearness of the water), the net is gradually withdrawn towards the surface of the water, which when near, the man suddenly drags it up with its contents, releasing the tame fish for a future decoy, and killing the others for food. The fish taken in this manner are of the parrot bill species, and an old decoy is much esteemed."

Being supplied with fresh necessaries, the vessel began to cruise in an easterly direction towards the Kingmills Group of Islands, in their further search for whales. By the middle of November they were among the Admiralty Group of Islands. When opposite St. David's Island, several canoes came off, and the natives of them are described as follows:—"They are rather under the middle size, of a copper colour, with coarse features like the Papoos to which they are allied; viz.: large mouth, tumid lips, and large uneven teeth. Their hair is black and of two sorts; some of them like the regular Papoos, having it half woolly and slightly frizzled; the others have it more strong and nearly straight. It is worn 6 or 8 inches in length and, when half woolly, bunches out into a frightful mass. Almost one half of them were covered with herpes similar to the Marianna Islanders. Their native costume is a white belt about 4 inches broad and 5 feet long, wound round the middle and crossed between the thighs; besides this they wear no other clothing. They seemed fond of ornaments and wore necklaces composed of little pieces of blackened cocoanut shell, white and red shells, variously threaded on a bit of cord, displaying considerable taste; some of them had girdles of a similar construction round the middle, and bracelets round the wrist; their finger rings were many pieces of turtle shell parallelly tied together and passed on the fingers. The pendulous parts of the ears were perforated with a large hole, into which some had a bunch of leaves inserted, and others the hooks they had received.

The islands are three in number, mere little sand-heaps covered with cocoanut trees, which are almost their only vegetable food. To scrape together a scanty subsistence the sea is had recourse to, and the chief part of their time is spent upon the reefs surrounding the islands collecting their marine inhabitants in the form of shell-fish, fish and turtle. Their canoes only contain 3 or 4 people, are built of various pieces tied together, and are furnished an elevated poop and prow which are reciprocally interchanged according to the tack on which they stand, for one side is always to the weather. This weather side is provided with a triangular outrigger with netting over its surface, and at its extremity a canoe-shaped solid log, which floats on the surface and gives the canoe its steadiness whilst the sail is set. The sail is formed like the Carolinians', triangular, with the apex inferior. I presented them with the seeds of various tropical fruits such as oranges, pumpkins, melons, Atas, etc., which, in the space of a little time may somewhat increase their comforts, though I conceive that their poverty is more to be attributed to the narrow limits of their soil than any other cause."

On Christmas Day, 1831, we were fortunate in getting among whales, and got several barrels of oil from them. January found them in the vicinity of Moratay, and here we were joined by another whaler. In February we sent boats ashore to Bruno, an island where a year before they had gone in order to replenish with fresh water and food supplies. Thence the ships sailed towards Timor, meantime on the outlook for whales. After much trouble and disappointment due to calm and adverse winds the whaler reached Batygady on March 28th to allow of inspection of their catch, which was found to be leaking from the barrels in the hold. Part of the fore deck collapsed while here. About the end of April the whaler left and began to cruise the Timor seas to get more whale oil, with more or less success. On the 28th of June, whales were seen, and it was resolved as most of their barrels were full of oil, to make this the last catch, and thereafter make for Batygady in order to replenish and prepare for the welcome news that the whaler would face towards home. July 15th saw them weigh anchor, and then began the long voyage home. The whaler was rather the worse of wear, and Dr. Lyell tells us that to keep dry and comfortable at night he slept on the top of two trunks and protected himself from dropping moisture by the use of old pieces of canvas. After passing Graciosa, Dr. Lyell amused himself by observing the breeding habits of cockroaches, which had become a positive pest on the ship. He also mentions that the egg of the cockroach is chosen by the hammerfly as a nidus for its young; he states, however, that he was never able to ascertain when, where and how the ovum of this fly was insinuated. He discovered another fly which also used the cockroach egg as a nidus for her young. With moderate and strong gales of wind, in eleven more days the English Channelwas reached, and on the morning of December 3rd the Isle of Wight was passed.