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LIST OF THE CONTRIBUTORS,

WITH REFERENCES TO THE SEVERAL ARTICLES CONTRIBUTED BY EACH.

1876, Feb. 26.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

SCIENCE.

PAPERS READ BEFORE THE ACADEMY.

I.—On Heat as a Factor in Vital Action (so called). By George Sigerson, M. D., Ch. M., F. L. S.

[Read June 24, 1872].

VARIOUS opinions have been expressed concerning the nature of Life. Some regard it as a peculiar agency, essential to the development of organized creatures, giving to them the first impulse and guiding their development, until the close. With them it is an entity, incomparable with any forces manifested in physics, and inscrutable from a physicist stand-point. Others are content to use the word to cover the total phenomena displayed by an organized Being, from end to end of its career; while a third party employ it to designate a mode of activity, peculiar to such beings, and distinguishing them from inanimate bodies.

Such views, however hypothetical, influence those who entertain them, to no small extent, and, perhaps, occasionally make those partizans who would otherwise be inquirers. Although theories may sometimes be of much advantage, it can do little harm when we find them clashing to put them aside, and leave the question in dispute an open question, whilst we give freedom to a search after facts, waiting for their aid to form an opinion. The process is less attractive, and much slower, but it may possess the qualities of greater solidity and permanence.

For these reasons, I have ventured to invite attention to a portion only of the many phenomena whereof Life is made up—though this portion, it is true, has been held to be highly characteristic and remarkably distinguishing,—I refer to certain of those movements which have been termed vital movements.

"One characteristic of every kind of living matter," Dr. Beale observes (Protoplasm, pp. 402), "is spontaneous movement." It requires to be noted that there the term "spontaneous" implies a foregone conclusion. In order that the question should be an open one, it is necessary to amend this, and say—"One characteristic of every kind of living matter is movement, the causes of which are unknown, and which therefore has been called 'spontaneous movement.'"

"This," he adds, "unlike the movement of any kind of non-living matter yet discovered, occurs in all directions, and seems to depend upon changes in the matter itself, rather than upon impulses communicated to the particles from without."

Now, from facts which have been under my observation during the space of two years, I have been brought to believe that similar movements take place in matter which would be called non-living, and that they, occurring in all directions, are due to a transformation of heat into a propulsive force.

Dr. Beale describes the alterations in form to which he has thus alluded as characteristic of vital matter: and as they to a considerable extent simulate those alterations in non-vital matter, it is desirable to give his words:—"The alteration in form," he remarks, speaking of some minute amœbæ—the most minute he could discover—"was very rapid, and the different tints in the different parts of the moving mass, resulting from alterations in thickness, were most distinctly observed. The living bodies might, in part, be described as consisting of minute portions of very transparent material, exhibiting the most active movements in various directions in every part," . . . "and," he adds, "capable of absorbing nutrient materials from the surrounding medium." That we must eliminate, as not being simply the manifestation of so-called vital motion. He proceeds: "A portion which was at one moment at the lowest point of the mass would pass in an instant to the highest part. In these movements one part seemed, as it were, to pass through other parts, while the whole mass moved now in one, now in another direction, and movements in different parts of the mass occurred in directions different from that in which the whole was moving." "What movements in lifeless matter," he asks, "can be compared with them? The movements above described," he adds, "continue as long as the external conditions remain favourable; but if these alter, and the amœbæ be exposed to the influences of unfavourable circumstances—as altered pabulum, cold, &c.—the movements become very slow, and then cease altogether."

Now, my attention was called to movements, very like these, which take place in non-vital matter by certain phenomena which I observed to occur under the microscope, in the minute globules of pyrogenic oil, which float about in the tobacco smoke. These globules, as I stated, at the time seemed twirling about like so many monads—but more than this, they seemed to alter their form. Conscious that rapid changes of plane might account for some of this, and might be a source of error, I pushed my inquiries further—though here, I may observe, that if such change of plane were remarked when taking place in living matter, they would run a risk of being called vital movement.

To represent the consistency of the amœbæ a somewhat viscid body is requisite, say an oleaginous fluid. By bringing drops of this into contact with a heated fluid, at various temperatures, I found that—1st, when the subjacent fluid was cold no motion took place; 2nd, when it was very hot, no movement occurred.

3rd. There is a stage, differing for different substance, at which rapid movement is given to the globule. At this stage, certain alterations in the colour of parts seem to mark a change in density, then various alterations of form occur. Thus the globule may alter into a ring, this globule divide at one portion or at several portions of its circumference, and re-form rapidly into globules, and these changes may proceed for some moments; then they will cease. That this stoppage is due to some acquired tolerance of the heat, is shown by the fact that a new drop will undergo similar changes at this temperature.

If the temperature be lower, the motions will be slower. Sometimes no eversion may take place; then we may note simply various protrusions from different parts of the periphery, and the globule may change its rounded to an angular form. To accomplish these changes, there must of course be transference of particles, and some of these may at times be noticed passing their neighbours.

There is sometimes a movement of the globules from one part of the surface of the fluid to another; thus the first contact of the heated fluid occasionally scatters its component parts in all directions.

In such cases as these, it is manifest that the alteratious, transformations, and changes of locality as well as of shape, are due to the conversion of heat into a motor-force acting through the physical basis of the viscid globule. The acquired tolerance of external influences is not unknown in vital matter.

The description which Dr. Beale gives of the movements in a mucus corpuscle, applies to the non-vital movements, to a considerable extent. "No language could convey," he remarks, "a correct idea of the changes which may be seen to take place in the form of the living mucus or blood corpuscle: every part of the substance of a corpuscle exhibits distinct alterations within a few seconds. The material which was in one part may move to another part. Not only does the position of component particles alter with respect to one another, but it never remains the same: there is no alternation of movements. Were it possible to take hundreds of photographs, at the briefest intervals, no two would be exactly alike, nor would they exhibit different gradations of the same change; nor is it possible to represent the movements with any degree of accuracy, because the outline is changing in many parts at the same moment. I have seen an entire corpuscle move onwards in one definite direction for a distance equal to its own length or more. Protrusions would occur principally at one end, and the general mass would follow. . . . From time to time some of the pear-shaped protrusions are disturbed from the parent mass, and become independent masses of germinal matter, which grow until they become ordinary pus corpuscles. Are these phenomena, I would ask, at all like any known to occur in lifeless material?"

If we abstract the questions implied in the words "germinal," and "growth," I think our answer may be in the affirmative.

We can follow him into his examination further. "A bulging may occur" in lifeless as well as in living matter "at one point of the circumference, or at ten or twenty different points at the same moment." But he cannot prove that "the moving power evidently resides in every particle of a very transparent, invariably colourless, and structureless material." It seems to do so; but it would also seem to reside in every particle of the lifeless matter, when changing, if we were not well aware that the change is due to a difference of temperature.

It appears to me that various kinds of organized matter have what I might term specific temperatures, the limits of which vary in different substances—below the lowest as above the highest they are motionless. This holds good of lifeless as well as of living matter.

The objections which Dr. Beale raises, justly enough, to certain theories do not here apply. He says, "because molecules have been seen in some of the masses of moving matter, the motion has been attributed to them. It is true, the molecules do move, but the living transparent material in which they are situated moves first, and the molecules flow into the extended portion."

This may be likewise noticed in a fluid in which are granules, when it protrudes under the influence of heat. The fluid is acted on; the granules are drawn with it.

"The movements," he adds, "cannot therefore be ordinary molecular movements. It has been said that the movements may result from diffusion, but what diffusion or any other movement with which we are acquainted at all resembles them? Observers have ascribed them to a difference of density of different parts, but who has been able to produce such movements by preparing fluids of different density? Nor is it any explanation of the movements to attribute them to inherent contractility, unless we can show in what this *contractility* essentially consists. Some dismiss the matter by saying that the movements depend upon the property of contractility, but the movements of biological matter are totally distinct from contractility, as manifested by muscular tissue.

He adds: "I have often tried to persuade the physicist, who has so long prophesied the existence of molecular machinery in living beings, to seek first in the colourless, structureless, living matter. But he contents himself with asserting that such machinery exists, although he cannot see it or make it evident to himself or others."

The instinct of the physicist, even if it were no more than an instinct, was, I think, right in this matter.

For:—

First. By the action of heat we can produce various alterations in form of lifeless matter, similar to those which are seen occurring in living matter in the cases quoted.

Second. In order that such changes should occur in living matter, heat is absolutely necessary. Cold delays and stops them, as in the case of the lifeless matter. A certain quantity of heat is needed. Too much as well as too little heat causes cessation of movement; there is a maximum as there is a minimum limit.

We come now to another class of movements which have likewise been termed vital. I refer to circulatory movements, such for instance as intra-cellular rotation, and cyclosis. In a given cell, we may occasionally observe its fluid contents in motion, made visible by a number of little granules that are carried along with it. This movement may be simple rotation, or it may take place in a spiral direction; though different courses may be taken in adjoining cells, the movement usually keeps on, in one direction in the same cell. Various ingenious theories have been devised to account for this.

If, now, we take a drop of oil and approach it to the flame of a candle, it can be seen that the oil, first at rest, is set in motion, slow or quick in accordance with the less or greater degree of heat exhibited. A little dust shaken into it allows the rotation of the granule-bearing currents to be easily observed by those who have a keen vision for minute objects. A slender baton of wax may be used: approaching the flame, the point melts, a drop forms, and then rotation is set up. If instead of having a rounded drop, we confine a fluid in a glass vessel shaped like a long cell, the fluid inside, by approximation to the flame, can be caused to move longitudinally. In a free fluid the particles are caused by heat to describe an ellipse—they seem to return in their courses, and this appears to be the case where heat impinges on the surface, so that we might expect to find a kind of circulation or rotation set up in water under the influence of the sun, apparently similar in kind to the motion of the celestial bodies.

To return to rotation in cells:—

First. Heat is capable of causing rotation in fluids.

Second. The rotation observed in cells absolutely requires heat. It chilled, the motion is slackened; if set under a certain degree of cold, it is stopped altogether.

Movement displaying different phenomena is that which has been termed cyclosis. This is shown in a plexus of latex-bearing vessels; it has been described as analogous to the capillary circulation in animals. There is no organ to make a *vis a tergo*, and yet there is movement through vessels in which there is no contraction; neither can it be attributed to a *vis a fronte*. It seems to take place in all directions, and has been considered a peculiar vital movement connected with formative functions.

If now we bring a heated body over the surface of a fluid, we will find that currents will be formed in all directions. In one case, under a heated point, I noticed an instance of perfect rotation. Usually, however, the currents are formed and proceed in all directions, carrying with them any grains of dust that may be in the fluid. The net-work of laticiferous vessels, anastomizing with each other, lies under the influence of the sunlight, as an exposed plane.

First. Heat is capable of producing various currents, moving in diverse directions.

Second. Heat is absolutely required in order that the movements in the latex vessels shall be produced: under little heat they delay; more heat quickens them.

II.—On Changes in the Physical Geography of Ireland. By George Sigerson, M. D., Ch. M., F. L. S.

[Read June 23, 1873.]

It is impossible to read the first pages of our ancient annals without being struck by the frequent mention of certain singular phenomena, the periods of whose occurrence are referred back to the earliest commencement of our history. With great sobriety of diction, and circumstantial precision of statement, we are told that in certain years there burst forth certain lakes, which are duly named, and that in other years there were eruptions of other lakes, and also eruptions of rivers. The dates and names are set down for every case.

Now, at first sight, these things seem so improbable, that the reader is inclined to believe the record to be erroneous, either fundamentally in fact, or superficially in the misstatement of ordinary incidents. Floods, it might be argued, have been magnified into the eruption of rivers, and the overflow or inundation of a lake into the outbursting of a new lake. There is another view also which is seemingly shrewd and very plausible. It is that the first discovery of lakes and rivers was marked down as the period of their first appearance. The historian O'Halloran may be allowed to state this view, as he does it with much earnestness. In reference to the recorded eruption of some lakes and rivers, he says: "It is recorded that at this time there were found in Ireland, but three lakes and nine rivers, whose names are particularly mentioned; but from this it appears probable that the parts of the country in which these lakes and rivers appeared were only what were then known; and, that as their successors began to explore and lay open other parts, the rivers and lakes then appearing, were entered into the national annals as they were discovered; but, as no previous mention could have been made of them, and that the different periods at which they were found out were distinctly marked, succeeding annalists have dated the first bursting forth of each from the time of its discovery. Our writers are very exact in the times in which these rivers and lakes appeared; it cuts a conspicuous figure in our history, and proves the extreme accuracy of our early writers;

but a very unjustifiable credulity in their successors, who could suppose the first discovery of them to be their first rise. . . But as it appears to be almost a certainty, that (with a very few exceptions) rivers and lakes are nearly coeval with the creation, the reader will, I hope, excuse my taking no further notice of this part of our history."

Now, I confess, that on first giving attention to these records identical speculations presented themselves as ingenious and satisfactory; they accounted for everything by explaining all away. Fortunately, the language of the annals is not ambiguous, and it is impossible not to perceive that when the word eruption is employed, something is meant quite different from inundation, a term also used. Again, O'Halloran's hypothesis falls before the fact that those lakes and rivers which, from their position and size, were most readibly discoverable, are not mentioned first, some of them not at all. Of two neighbouring lakes, the larger and more accessible may be left unnoticed, whilst the eruption of the smaller is chronicled. Finally, if his hypothesis were valid, it would follow from the data given, that Ireland was first colonized in that part which is now the county Mayo, that the newcomers soon discovered Lough Conn and Lough Mask, but never found Lough Corrib; that they afterwards proceeded to prospect a few small lakes in what is now the county Monaghan, without ever having observed the Shannon's spreading sea.

It may, perhaps, be possible to account for the formation of a few lakes by some of the changes operated on the face of the country, by the progress of colonization. Here there is repeated mention of the clearing away of forests. Fire as well as the axe was doubtless employed in this work, and the charred remnants may occasionally have helped to block the path of flowing waters and bar the drainage of small areas. The removal of a forest from a given space itself removes a drainage organ of no inconsiderable power. Hales found that a sunflower with a leaf surface of thirty-nine square feet exhaled twenty-two ounces of water in the twenty-four hours; Knop, that a plant of maize, in three months and a half, exhaled thirty-six times its own weight of water. When we consider how extensive is the leaf-surface of trees, and how great the transpiration, a forest might almost be regarded as an engine for draining up a river from the earth and dissipating its waters through the air in the form of insensible vapour. Thence, it descends again in showers. The first effect of felling forests in Ireland, under the circumstances of the period alluded to, might have been therefore the formation of pools, streams, and lakelets—the secondary effects would be shown in their gradual drying up, when the land was exposed to the full rays of the sun.

But, although we may possibly account for the formation of some water courses and lakes in this way, we do not account for the emphatic employment of the term eruption, nor for the successive phenomena chronicled. It is to be noted also, that the clearances are not coincident in space, nor always in time, with the formation of lakes and rivers.

The eruptions recorded in the annals may be divided into two groups (which might be subdivided into minor groups), between the occurrence of which a long lapse of six centuries and a half is related to have taken place. However improbable may be the pre-Christian chronology here, as respects the events attributed to particular years, it seems reasonable to suppose that a succession of epochs might have been noted accurately. I am inclined to credit this, in the present case, for the following reasons: Following on a map the chronicled eruptions of lakes, I united the latter, so far as identified, by straight lines. To my surprise I found these lines arranging themselves north and south, in a direction parallel to the lines of longitude. Thus it was with respect to Lough Conn and Lough Mask in the west, to Loch Laighline in east Meath; and Loch Eochtra, or Mucnama, in Monaghan; to Derryvaragh and Ennel, in Westmeath; and to a few others. About four lines, running north and south, each including two or more lakes in their course, appeared on the map.

From the end of the Nemedian period, during all the Firbolgic and De Dananian days,* until the Milesian epoch had begun, no outburst of lake or river is recorded. A long interval of six centuries and a half, therefore divides the first great group of lake eruptions from the second group, in which the eruption of both lakes and rivers is mentioned. Now, it struck me as curious that the lines connecting the principal lakes enumerated lay in a different direction. Instead of running north and south they run obliquely from south-west to north-east. Thus, a line drawn from Clare to Belfast will fall more or less near eight lakes, whose eruptions are recorded, Anno Mundi, 3503—they are Lochs Graney (Co. Clare); Cimbe (now Hackett, Co. Galway); Loch Baah (Co. Roscommon); Ren and Garadice (Co. Leitrim); and Loch Laegh, now Belfast Lough. At this period, certain rivers break forth; and of these the Brosnac, the Socs (now Suck), and the Inny, flow towards this line from west and east, whilst others in the north, such as the Una in Tyrone, and the Callan in Armagh, and (perhaps), the Fregrabail (now the Ravelwater, in Antrim), appear related to it.

The next oblique line runs almost parallel to this on the north-west; it covers in its course the recorded eruptions of Loch Foyle, Loch Erne, and an irruption of the sea, forming what is now Drumcliffe Bay. Towards this line tend the three Finns, whose eruption is there recorded, and perhaps, some other streams named by the annalists, but not identified by recent writers. Here again, we find some isolated cases; and rivers are mentioned as having burst forth in the south-west.

Bearing in mind the evidences of change of levels which some of our beaches present, and the proofs of depression and elevation in the

* Lough Corrib [Loch Oirbsen] was formed in the Dananian period, according to the Book of Leinster.

Erne district, to which I drew attention in a former paper, it appeared to be highly probable, that in these lines we had indications of meso-seismal areas. Their directions seem to point out the directions of seismic energy, in the most ancient days of our history. It has been frequently found, where noted in latter times, to run in the directions of those lines. The apparent change from a vertical to an oblique direction, coincidently with the chronicled change from the first great group to the second group of phenomena, tends to confirm the statements of our annals, as far as they relate to remarkable natural events. That being so, it next became requisite to see whether earthquakes had been known to occur in Ireland; and necessary to ascertain whether such occurrences as those chronicled were such as seismical force would produce, and alone produce.

First: Earthquakes in Ireland.

In 1820, the shock of an earthquake was felt in Cork and neighbouring towns.

In 1534, the Anglo-Norman chronicles, state that an earthquake was felt in Dublin. The Four Masters make no mention of it.

In 1490, according to the Four Masters, "There was an eruption of the earth (Maidm-talman) by which a hundred persons were destroyed, among them the son of Manus Crossagh O'Hara. Many horses and cows were also killed by it, and much putrid fish were thrown up, and a lake in which fish is now caught, sprang up in the place."

In 1452, it is related, that the Liffey was dry for over two miles. The Four Masters say: "A very wonderful presage occurred in this year, some time before the death of the Earl (of Kildare), namely part of the Liffey was dried up, to the extent of two miles." [Although this does not prove the occurrence of an earthquake, it may indicate seismical action, as several such phenomena are on record, all more or less closely coincident with the occurrence of earthquakes near or at a distance.]

In 1266, mention is made by Anglo-Norman writers in Ireland of an earthquake, which is stated to have been felt in all parts of Ireland. The Four Masters, however, do not chronicle it.

In 1191, the river of Galway (according to the Annals of Kilronan) dried up, and a hatchet and spear were found in its bed.

In 1178, the same river, the Four Masters relate, was dried up for the period of a natural day; all the articles that had been lost in it from remotest times, as well as its fish, were collected by the inhabitants. O'Flaherty, in his account of Iar-Connaught, states, that ancient annals describe the river as having dried up from Friars' Isle (in the lake whence it issues) to the sea, from midnight till noon. It seems probable that there must have been an upheaval of the bed to account for such a phenomena.*

* In several cases where earthquakes have been recorded in recent times, as in Mr. Mallet's catalogue, the temporary drying up of rivers has also been observed to occur; sometimes the connexion may not be considered quite proven, as when, in 1785, the

In the fifth century, it seems that a remarkable earthquake took place which affected Tara. It occurred (it is said) when Odran, St. Patrick's charioteer, was assassinated. "And the cleric was angered," says the author of the Senchus Mor, "and raised up his hands towards his Lord, and remained in the attitude of prayer with his hands crossed, and there came a great shaking and earthquake at the place, and darkness came upon the sun, and there was an eclipse; and they say that the gate of hell was then opened, and that Teamair was in danger of being overturned, and then it was that Teamair became inclined."

It thus appears, not only that we have had earthquakes in this country, but that the farther we go back in authentic history, the more striking seem to have been their effects. This constant increase in seismical energy appears to point to the occurrence of still more vehement action in preceding periods—in those periods, for instance, to which so many eruptions of lakes and rivers are attributed.

Secondly: Are the phenomena recorded in our annals such as would have been produced by seismical action, and by that alone? We have seen that no other imaginable cause was competent to produce such results; it now remains to prove that seismical energy can produce them, and to give cases showing it to have wrought out analogous effects.

At the outset, it is noticeable that almost all the lakes and rivers

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river Teviot dried up suddenly, and remained dry for two hours, within a short time of the occurrence of an earthquake at Messina. Again, however, the same river suddenly dried up for four hours, nineteen days after a shock had been felt in 1786, at Campsic and Strathblaine, north of Glasgow. In other cases, however, the connection is unmistakeable. Thus, in 1802, whilst the ground moved "like waves of the sea," and partial subsidences and upheavals were noted, it is related that "the waters of the Orinoco rose so high [apparently] as to leave a large part of the river dry," correctly speaking, the river bed was upheaved. In 1820 a small river in east Gothland, Sweden, stopped at a certain spot, so that its bed was crossed dry-shod. In 1830, the Douro, in Portugal, suddenly dried, between Roa and Aranda, at 2 o'clock in the morning, and resumed its course at 10 A. M.. The river Alba de Tormes was interrupted in like manner. Garnier, in his Meteorologie relates, that, in 1833, after an earthquake had been felt at Linköping in Sweden, on the following night the river near the bridge of Montala stopped, and was raised up like a kind of sea. The bed could be passed dry-shod, although in general 60,000 tons of water pass under the bridge per minute.

If it be also remembered that, owing to earthquake action, the sea has, at times, retired from bays and the coast, rushing up again to a great height, it seems possible that the passage of the Israelities on dry ground through the Red Sea was assisted (physically) by seismical action. A strong east wind is mentioned as having caused the sea to go back, and pillars of cloud and fire were seen. It is to be remarked that clouds, flashing of fire, fire-balls, fiery red vapours, as well as thunder and lightning, frequently accompany earthquakes. In 1802, at Cahors (in France), and for forty leagues around it, a loud explosive noise was heard, preceded by a flame, directed from west to east, and accompanied by a southerly wind. At Beauvais, simultaneously with a shock, a globe of fire was observed moving from east to west, which disappeared with a loud explosion. At Albugnol, in 1804, the heavens were obscured by a dark mist, which resolved itself into a cloud, when in ten minutes five terrible flashes of fire issued, and after each flash a shock took place.

whose eruptions are chronicled, are situated, or arise in limestone districts. It is known that the strata of limestone may, and often do include subterranean reservoirs and channels of water; an instance of the latter is found in the case of the underground river near Cong. With, perhaps, an exception, the lakes found in districts from which limestone is absent, as Lough Foyle, Belfast Lough, are loughs which communicate with the sea, and may have received their waters from it. I now proceed to give parallel cases for those mentioned in the Irish Annals.

Eruptions of lakes constitute the first category of observed phenomena. The Irish Annalists chronicle the eruption or bursting forth of the following lakes:—

A. M. 2532. The eruption of Loch Conn and Loch Techeat.

A. M. 2533. The eruption of Loch Mask.

A. M. 2535. Loch Laighline sprang forth. The eruption of Loch Eachtra also.

A. M. 2859. Loch Derryvaragh and Loch Ennell sprang forth, and about this period sprang forth Loch Gall and Loch Ramor.

A. M. 3506. Eruption of the following lakes: Cimbe, Buadaig, Baad, Ren, Finnmaige, Greine, Riach, Da-Chaech, and Loch Laegh.

A. M. 3581. Eruption of nine lakes: Uair, Iarn, Ce, Sailean, Ailleann, Feabail, Gabair, Dubloch, and Loch Daball.

A. M. 3790. Death of the monarch Aengus. These are the lakes which burst forth in his time: Aenbeite, Saileach, and Na-ngasan.

A. M. 4694. Loch Melvin burst forth over the land in Cairbre.

Parallel cases. These have occurred usually but not necessarily coincidently with earthquakes, though the shock may not have been felt.

The cases recorded are compiled from Mallet's catalogue:—

A. D. 1790. Terra Nova, Sicily. The gradual sinking of a piece of ground, three Italian miles in circumference, to a depth of thirty feet, took place. From fissures in the soil burst forth vapours, petroleum, sulphur, hot water, and finally a stream of salt mud.

A. D. 1790. South America. A piece of forest land, resting on granite between the villages of San Pedro de Alcantara and San Francisco de Aripao sank eighty or one-hundred feet, and produced a lake four-hundred toises in diameter.

A. D. 1792. The ground opened about Tureguraqua, and lakes were found.

A. D. 1802. South America. A piece of ground one-hundred feet long and forty feet wide sank down, and a pool of water appeared in its stead.

A. D. 1805. Earthquake at Naples. At Bojano a lake made its appearance.

A. D. 1806. Siberia. A mountain, distant twelve versts from Krasnojarsk was replaced by a lake of three hundred feet in circumference, and one-hundred and eighty feet in depth, in some places; the water in which had the taste and smell of sulphur.

A. D. 1806. Italy. At the mountain of La Fajola a lake of sulphurous water was formed.

A. D. 1810. San Miguel, Azores. The village of Las Casas, consisting of twenty-two houses, disappeared, and a lake of boiling sulphurous water appeared in its place.

A. D. 1811. Earthquake felt in the valley of the Mississippi, Ohio, Arkansas. During the shocks, great clefts appeared in the ground, from which quantities of water, sand, and pieces of coal were thrown out. Large lakes were formed in many places The level of the ground was permanently raised and depressed in various localities.

The second category of cases includes irruptions of the sea. Of these, the Irish Annalists record the following:—

A. M. 2545. Rury, son of Partalon, was drowned in Loch Rury [the estuary of the river Erne], the Loch having flowed over him; and from him the Loch is named.

A. M. 2546. An inundation of the sea [sea-flood] over the land at Brena, this year, and this [loch so formed] is named Loch Cuan [now Strangford Lough].

A. M. 3506. The eruption of Loch Da-Chaech, now Waterford Harbour.

A. M. 3581. The eruption of Lough Foyle.

A. M. 3790. The eruption of the sea between Eaba and Loch Cetle, forming the creek of Drumcliffe.

Parallel cases: A. D. 1812. Marseilles. The sea retired, leaving the port dry, and rushed in again, inundating the quays.

A. D. 1817. Athens. The shock of an earthquake was felt, accompanied by an inundation of the sea.

A. D. 1820. Acapulco. The sea retired from half the bay, and returned, rising to a church on the highest side of the town.

A. D. 1821. Zante, Morea. The waters of the Alcyonic sea (a part of the Gulf of Corinth), rose suddenly, inundating the country and carrying away houses.

A. D. 1822. Chili. The sea rose to an amazing height, fell, and rose again, and thus continued for a quarter of an hour

The third category includes the sudden overflowing of lakes. The Irish Annalists chronicle but one, I think of such occurrences:

" A. M. 3751. A battle was fought against the Ernai, a sept of the Firbolgs, where Loch Erne is. After the battle was gained from them the lake flowed over them." It would appear then that this was not an eruption but the sudden overflowing of an already formed lake.

Parallel cases: A. D. 1789. Iceland. Lake Thingvallevate became dry in places where it had formerly been twelve feet deep, and overflowed its eastern shore.

A. D. 1817. The waters of the Lake of Geneva were momentarily raised.

A. D. 1820. Shock at Port Glasgow. The waters of Loch Lomond were agitated, and rose somewhat so that persons crossing it were alarmed by the sudden rippling of the waters.

A. D. 1823. The waters of Lake Erie rose suddenly to the height of nine feet on the Canadian shore, carrying men and boats inland with irresistible force. The waters then fell but rose again twice to a height of seven feet. It was reported that the shock of an earthquake had been felt.

In the fourth category I have placed the eruptions of streams and rivers. The Irish Annals enumerate several such outbursts, which all are included in the second and later group.

A. M. 3503. The eruption of the seven Brosnas—now two, the other seven being tributary streams; of the nine Righes, in Leinster; and of the three Ninsionns, in Tirerril.

A. M. 3510. The eruption of the Inny, in Westmeath; of the three Socs; the Suck and its affluents, in Connaught; and the Fregabail, now Ravelwater, Antrim.

A. M. 3520. Irial son of Heremon died. During his reign took place the eruptions of the Suir, the Feil, the Ercere, in Munster; the three Finns in Ulster, and the three Corindes.

A. M. 3656. The three black rivers of Ireland burst forth, the Una, Tyrone; Forann and Callan, Armagh.

A. M. 3751. The monarch Fiacha died. It was in his reign the springing of these rivers first took place, namely, the Fleasg, the Mang, and the Labrann, in Kerry.

A. M. 4169. The monarch Sirna died. In his reign of a century and a half, took place the eruptions of the rivers, Skirt, Doailt, in Monaghan; the Nith (river of Ardee, Louth); the Laune, in Kerry; and the Slaine, a tributary of the Boyne.

Parallel cases: A.D. 1797. Quito. The ground opened about Tunguragua in enormous clefts, from which volumes of water and stinking mud issued, forming lakes in many places, of considerable extent.

A. D. 1802. The earth opened at Bucharest, and greenish water was poured forth, diffusing an odour of sulphur through the whole city.

A. D. 1804. At Badisen, Silesia, springs suddenly burst from the mountain, and the Elbe and neighbouring rivers inundated their banks.

A. D. 1804. Spain. Near Albugnol the mountain was cleft, and a stream was poured forth on the lower part of the town. Springs disappeared and new ones appeared.

A. D. 1809. Capetown. In Blanweberg's valley fissures appeared, and muddy water was thrown up to a height of six feet through holes in the sandy soil.

A. D. 1812. At Caraecus, South America, an immense torrent of water burst forth.

A. D. 1828. Peru. At Surras, streams of water burst forth from the earth.

A. D. 1828. Caucasus. Three large springs burst forth, fissures and other springs appeared.

A. D. 1829. Spain. At Murcia, fissures opened, and from some small holes sand was spirted out, from others water.

A.D. 1840. Ararat. Water spouted up from holes in the ground; new springs flowed, and old ones dried up.

Whilst in all the categories of general phenomena we find parallel phenomena—the results of seismical action—thus produced, there are certain special phenomena which, though apparently incredible, find also their analogies in the effect of seismic force. Take for example, the incidents of the eruption of the earth which resulted in the formation of Meem Lough, A. D. 1490. Many men and cattle were destroyed, and putrid fish were thrown up. Destruction, according to evidence of modern cases, may be worked by the opening of chasms which swallow up houses and men, by the sudden outburst of water, or by the expulsion of suffocating vapours, such as burst forth from the lake of Quilotoa, South America, in 1797, and which proved fatal to herds of cattle grazing on its shores. The death of fish is a frequent incident, under such circumstances, in any adjacent or previous formed pools: thus in 1824, a lake near Lucca was observed to be greatly agitated, a sulphurous smell came from it, and many dead fish were seen floating upon it. At Manilla, one of the Philippine Islands, the earth opened in 1844, and dead fish were observed immediately after floating on a neighbouring river. Similar occurrences marked the disappearance of Lake Telchef, in Lithuania, which I described in a previous paper (Proc. R. Irish Acad. Science, Vol. I., Ser. II., p. 224, foot note).

Other special phenomena which I consider to be explicable, by the supposition of seismical action—the prevalence of which in ancient times is now, I hope, proved—form an extremely curious and interesting group. They are interwoven with the legends, the superstitions, and the poetry of the people.

Some legends refer to lakes. At times, it is said, these sheets of water appear troubled without apparent cause; whilst all is still, ripples and waves break over them, and vaporous forms ascend from the depth, whose embrace sometimes carries the gazing mortal away from this world to the mysterious pleasures of another. Now, when we become conversant with the phenomena of seismical action, nothing can seem more obvious than that all these legends had their foundation in the fact that the waters of lakes do become greatly agitated without apparent cause, and emit vapours of a kind often sufficiently powerful to relieve man from the anxieties of this life. Knowing of such vapours and finding that some who had been subjected to their influence lay dead when they had passed, the poetic imagination of the people figured that the spirits had been stolen to fairy land.

In other cases, there is not only strange commotion observed, but unwonted sounds, as of the bellowing of monstrous animals and the hissing of serpents are heard. In our Ossianic poems, and elsewhere, these are mentioned and attributed to the convulsions and writhings of the terrible Piast, supposed to inhabit such lakes. Reading those romances, one is inclined to believe them baseless—nevertheless, they have a foundation in fact. Thus, coincidently with the Lisbon earthquakes of 1755 and 1827, an extraordinary noise was heard in the lake of Salungen, in Saxony; and in 1799, at Cumanas, in South America, the waters of a lake became exceedingly troubled, and a strange subterranean noise was heard proceeding from it, comparable to a "prolonged bellowing," and at other times to a hissing sound. To a pastoral people hearing such sounds, nothing could be more natural than that they should consider that some animal infested the lake, troubled it by its movements, and terrified them by its roaring.

Some legends refer to wells. It is usually said that a well was laid under a magic spell of some kind, which to break insured destruction. In a hapless moment the warning is forgotten; a damsel omits to replace a cover or perform some stipulated act; forthwith the waters arise, overflow, inundate the valley, and overwhelm perhaps, a town. This, for instance, is the tradition of the origin of Lough Neagh, and Giraldus Cambrensis relates that the fishermen used, in clear weather, frequently to point out to strangers the submerged ruins. Moore has commemorated the incident in verse, since which time it has been taken as a purely poetical fiction. Nevertheless, it may have been founded upon fact. Under seismical action, wells have frequently attracted attention; sometimes the water fails, and they dry up, sometimes it arises and overflows. In 1809, in the Abruzzi Ulteriora, at Aquita, some springs appeared to boil up. In 1832, at Foligno, a man going to draw water at a well found it filled and overflowing, then came a shock, and when he returned it was empty. Ancient dry wells, on the other hand, have suddenly filled up, and the eruption and outbursting of new springs and considerable torrents are not infrequent incidents. At the time the occurrence happened in an Irish district, the overflow of the well doubtless indicated seismical action, and was accompanied or followed by shocks and subsidence of the soil, such as we have seen. Villages have thus been occasionally overwhelmed with waters, but I find a curiously parallel case to Lough Neagh, in Italy. There, whilst an earthquake was felt in north Italy and Switzerland, the castle of Manguin, situated on the shore of a small lake, sank down and was covered by the water. There, also, the fishermen might have pointed out to strangers, "the towers beneath them shining."*

It only remains to consider the phenomena which gave rise to the fable of the Land of Youth, Hy-Brasail, the Land of the Blest.† An

* The sudden subsidence of the foundation, and the vibration of shocks would scarcely fail to shatter buildings thus affected. But their ruins would exist. It is certainly curious that Giraldus Cambrensis should be able to state that the fishermen, at that time, frequently showed the submerged towers to wondering strangers on clear days. "Piscatores aquæ illius turras ecclesiasticas, quæ more patriæ arctæ sunt et altæ, necnon et rotundæ, sub undis manifeste sereno tempore conspiciunt, et extraneis transeuntibus, reique causas admirantibus, frequenter ostendunt."

† "The inhabitants of Arranmore are still persuaded that, on a clear day they can see from this coast Hy-Brasail or the Enchanted Island, the Paradise of the Pagan Irish, and concerning which they relate a number of romantic stories." *Beaufort*, Ancient Topography of Ireland.

It has been stated that a similar "Enchanted" island was observed off the coast of Donegal.

enchanted island has been supposed to exist beyond our western shores, which became visible on some rare occasions of old, and to some privileged persons. Now, however beautiful and improbable the tradition may be, it has become plain to me that there really was such an island. The legend may have been perfectly accurate as to the statement that at one time it was seen, and at another it became invisible.

There are several instances on record, even in recent times, when islands have been raised through the disparted waters of the sea, remaining for a time above its surface, but finally disappearing. Thus, in 1707, after a shock, there was seen from Santorine a floating rock, which stoutly arose above the waters, forming an isle. In 1803, an island rose in the Claveezer See, in Holstein; it was afterwards washed away by the waves. In 1814, after an earthquake shock had been felt, it was noticed that a small islet in the Greek Archipelago, named Salomon's Island by the Turks, had suddenly disappeared. In the same year, a small islet made its appearance in the Sea of Azov, but was afterwards washed away.

From the Irish records it appears that some formerly known islands have disappeared from off our western coasts; and from what we may infer from legendary lore it appears probable that the story of Hy-Brasail is based upon subsidence of islands due to earthquake action. It is possible that, in ancient times, an archipelago of scattered islands may have stretched out towards the American continent, and if this were so, it is possible to conceive of such adventurous voyages as that of St. Brendan, without greatly straining the imagination. The ocean desert would then have had its oases.

The conformation of the bottom of the Atlantic basin lends support to the supposition, and strengthens the opinion that Ireland must have lost ground to the encroaching waters of the west. Even off the east coast, it appears also to have ceded portions of its territory. On Keith Johnson's Physical Map a tract is marked out, with the observation that "this region was probably land during the period of the Irish Elk."

It would be a curious question to investigate how far the ancient Irish legends of Hy-Brasail, and the classic legend of Atlantis, might bear upon the former existence of that supposed submerged continent, which now produces nothing but forests of sea-weed.

Geological evidence: The labour of collecting geological evidence for each case mentioned, would, as may be supposed, be quite beyond the limits of my present purpose and opportunities It may suffice, however, to call attention to certain acknowledged facts which tend, unmistakeably, to corroborate the statements made with regard to the action and influence of seismical energy, in former times.

North and south, along the coast-line of this country, the presence of raised beaches gives proof of permanent upheavals; evidence of subsidence may also be found, whilst the character of the strata in certain districts confirms the view that alterations of level, resulting in the eruption of water, have taken place.

In the west, whilst local tradition relates that off the west coast of Achill there is a beautiful land sunk beneath the waves, with its fields and city, the physical appearance of Sliav Cruachan is such as to suggest partial subsidence. "There are evident indications here of Sliav Cruachan having been sliced down," writes the Rev. Cæsar Otway,* "and left as it were the palpable remnant of some great convulsion; for just behind the precipice where it is highest, and about twenty feet from the brow, an anterior chasm is seen, forming an enormous and rugged fissure for hundreds of yards along—in some places hundreds of feet deep; and this shows that when the mighty blow was given, and while half the mountain was falling down, this crack took place. It was but a chance that this great slice did not go down along with the rest."

That subterranean waters exist, which, under the influence of earthquake action, may be brought to light is a proven fact. In the neighbourhood of Cong, the curious tourist may even now, by descending into a deep cavern, behold a subterranean river—one of several streams, which, percolating through the limestone strata, convey the waters of Lough Mask to mingle with those of Lough Corrib. In Nimmo's report upon the geological structure of Connemara, he, writing of this district, says: "The fletz limestone, passing under Lough Corrib, occupies the greater part of the provinces of Connaught and Leinster." The boundary of this rock runs nearly in a straight line to Oughterard, from Oughterard it turns to the north, and, crossing the lake, appears on the opposite, a little to the west of Cong, and occupies the southern margin of Lough Mask. The boundary now is lost in Lough Mask, but reappearing at the upper or northern extremity, turns off towards Westport; about three miles short of that town, however, it turns north-east to Castlebar. "It is particularly worthy of remark," he adds, "that along the borders of the fletz limestone there are series of vast caverns usually with subterranean rivers traversing them. Though this be a common occurrence in the limestone countries, there are few instances, I believe, so remarkable as in this tract. A succession of lakes having no visible outlet occurs in the same situation; of these, Lough Mask is by far the most considerable. The drainage of a country of two-hundred and fifty square miles sinks here in a basin of forty square miles, and after a subterranean course of two miles rises in several magnificent fountains to join Lough Corrib. On the south of Lough Corrib also, the Ross Lake has no visible outlet, though it receives the waters of a large tract of mountain. The waters of Lough Mask are visible on the passage in several large caverns near Cong, but those of Ross probably rise in Lough Corrib, by an inverted syphon. There are two or three other smaller lakes, to the east of Ross, and probably of a similar description."

From their geological situation, Loughs Corrib, Mask, and Conn

* Tour in Connaught.

and minor lakes—lying north and south—seem to have been produced at the same period, by earthquake action running in a direction almost due north and south.

Proceeding northwards, the record which relates to the eruption of Lough Erne appears, also, corroborated by certain physical facts. According to the chronicle, the breaking forth of the water drowned some of the Ernai tribe, then upon its plain. The aspect of the locality indicates ancient changes of level; thus, Dr. O'Donovan, when describing it whilst on the Ordnance Survey, wrote: "I passed over the great cliffs that overhang the plain of Fweealt of Toorad. This Fweealt is a level district running about five miles along the north-west bank of the great Lough Erne. The name (Faoi alt) signifies 'under the height,' 'subrupian.' It is grand and beautiful, and seems to have been formed when the awful commotion took place that formed Lough Erne. It was by a depression of the earth, occasioned by some subterranean commotion similar to the one that in later times destroyed the city of Lisbon."* Distinct proof of a former upheaval is found in the remarkable discovery, which Professor W. K. Sullivan has communicated, of a dolphin's skull, which lay twenty feet beneath the surface of a bay, at Pettigo, near Lough Erne. It follows from this that the locality was once submerged, that the sea ran in as far as the site of the present town of Enniskillen, and that it was probably continuous with the Foyle, at Strabane and Derry. Thus, at that period, Donegal would have been isolated. Afterwards, there was a great and extensive upheaval, which raised this district so much that the surface of the Lough is now about one-hundred and fifty feet above the level of the sea at low water.

As there are raised beaches along the northern coast, it appears likely that they were elevated about the same period, and that the influence of earthquake action extended over the north of Ireland. It is recorded that the late Mr. Du Noyer discovered some flint weapons amongst the gravels of the raised beaches of Down and Antrim. If, therefore, we hold, as seems most probable, that the various upheavals in the province took place about the same period of time, we may come to the curious conclusion that those who fashioned and used the flint weapons, so discovered, may have been the contemporaries of the Ernai.

That there should be raised beaches at or near Lough Foyle is what we would anticipate from its seismical connexion (so to speak) with Lough Erne. Nor are they wanting. Instances of elevation may be detected on the west or Innishowen shore, from Moville to Port-a-dorus; on the eastern, or Derry shore, the effects of upheaval assume larger dimensions. Evidence of subsidence is also present. Thus, on the west strand, near Portrush, there has been found a large quantity of hard flaky bog, which, lying below high-water mark, is laid bare by

* Ordnance MSS., Fermanagh, Letters, p. 41.

the waves. "Every storm," writes Captain Portlock, "breaks up a new portion of it," covered though it be with sand and gravel, where not denuded. The presence of such a bog, which must have been formed free and above the waves, proves that the land here has sunk. As it contains leaves, nuts, rotten wood, and the elytra of beetles, it is plain that both animal and vegetable life abounded where now nothing is heard but the roar of falling billows.

Evidence of elevation is seen in the calcareous clays, containing marine shells, which have been found at heights varying from one hundred to four hundred and fifty feet above the sea. One curious instance is the bowl-shaped hollow, north of Portrush, explored by Mr. James Smith; it is ten feet only above sea-level, and contains a large quantity of sand mixed with various marine shells. "This shelly deposit," writes Mr. Smith, "seems to have been a sheltered bay, into which the shells have drifted, with a small admixture of land shells washed down by floods." In the letters descriptive of Magilligan, which its rector, the Rev. Robert Innes, published in 1725, the peculiar physical appearance of the locality was noted. Although he wrongly cited the Deluge as the cause of what he described, his description is accurate and valuable. The evidence of upheaval was recognised by him. "That this land," he wrote, "was formerly sea, I think there is sufficient reason to believe; for along, at the foot of the mountain and all the coast, is the old bank to be seen, to which the sea hath formerly flowed, at the foot of which everywhere there is sea-sand and shells to be dug up." "The lowland of Magilligan," he adds, "is divided into ridges, or, as we call them, dryms [properly druim] of sand, from one hundred to five hundred yards broad, highest in the middle and sloping on each side to marshy ground, which we call misks, commonly as broad as the dryms; the dryms are generally from six to twelve feet higher than the misks, but on the north side (next the ocean) the dryms and misks are narrower, and some of the dryms thirty or forty feet higher than the misks. Both the dryms and misks are parallel almost." The cause of these (the result of the action of sea and winds and of seismical elevation) he considered to be the Deluge. He notes that, owing to water-action as then going on, land had lost a hundred yards within a man's memory. And he reports an interesting local tradition, saying, "if we can make anything of Irish fables, the flats of Lough Foyle, which extend in some places a full league, have been formerly part of this land."

If the "eruption" of Lough Foyle, recorded in the annals, were an irruption of the sea, much, if not all, of its present basin may have been dry land. It would seem necessary that the river Foyle should have followed its present direction; but, in fact, that need not have been. The valley of Pennyburn, which crosses the isthmus of Innishowen, a little to the north of Derry, and which Captain Portlock accurately reports as "exhibiting a channel so natural and well-defined that it is impossible to resist the feeling of being in (the bed of) a river or strait"—this valley I proved to have been a water-passage in recent times. Within three hundred years, the waters of the Swilly and Foyle were connected by it. What I would here add is, that in remote times the river Foyle itself (going partly or wholly by the western side of Derry Hill) has passed through this valley into Lough Swilly. Though farther geological investigation* is required to determine the accuracy of this supposition, it receives support from the physical appearance of the district, and from the gradual drying up of the valley-channel, when the Foyle found another vent. The most ancient map of Ireland shows only one lough (Swilly) in this district, and the ancient chronicles do not notice the existence of that great sheet, now known on the map as Lough Foyle. They did, indeed, make use of the name, but it was applied to a large lake (now obliterated) which I proved to have spread out its waters between Strabane and Derry. The river which passes through the alluvial deposits that filled the lake, like a current through a frozen sea, still retains the name of Lough Foyle, and when swollen by floods resumes some of its former sway over the submerged flats.

Passing to another question, the eruption of Lough Neagh, there is here also to be found geological evidence in support of the statement of our ancient chronicles, which asserted that it was formed suddenly and (to them) mysteriously. "Lough Neagh," Captain Portlock remarks, "is itself apparently the result of a great crack or subsidence of the strata."

It only remains to say that evidences of upheaval are visible in the deposits reaching up the Dublin Mountains, in the levels along the Lee above the City of Cork, and southwards in the raised beaches of Kerry; whilst proof of subsidence is found in the fact, communicated by Professor W. K. Sullivan, that ancient bog and forest stretch out beneath the sea, off the coast of Waterford.

The more the question is investigated, therefore, the more do proofs abound to demonstrate that, in ancient times, this island was

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* Having established, in a Paper entitled "Discovery of Fish Remains in the alluvial clay of the River Foyle, &c.," the insulation of Innishowen, I pointed out that the escheatment map of 1609 showed another channel connecting the Foyle and Swilly, running from "Cargan" (now Carrigan) to "Kilmacatrem Castle," and that Malin was insulated. This was but briefly noticed, as corroborative evidence was not then accessible. Since that time I have gone over the locality, and found confirmation of the map in the conformation and character of the soil. The former insulation of Malin is very evident, though at present the water channel is occupied by a great bog. The substratum, however, is either potter's clay or gravel. The ancient channel or strait ran between Culdaff and Malin town, a distance of about three miles in a direct line, being somewhat shorter than the isthmus at Pennyburn. Interspersing the vast bog which has now largely occupied its place, are oases of clay land, formerly islands, and about midway on the moor is a village whose name, Aughnaclea, signifying "Ford of Hurdles," indicates the former presence of water. As the channel must have existed in 1609, when the escheatment map was made, and as a great bog has since been formed, we have here desirable and valuable data for arriving at the rate of bog growth. Plainly this great bog cannot be many centuries old.—*Vide* Proc. R. Irish Acad., Vol. I., Ser. 2, Science, p. 212.

greatly subjected to the influence of seismical action. The following conclusions may be drawn :—

1st. The descriptions given in the annals, or woven into legends, of the various physical phenomena mentioned coincide closely with what we know, in a sure manner, of the results of earthquake action in modern times.

2nd. The evidence of earthquake action in Ireland, given thus unconsciously as to cause by our ancient annalists, is doubly valuable because of its proven accuracy and undoubted antiquity.

3rd. Our ancient records form, probably, the largest collection of ancient seismical indications and results now in existence.

4th. Ireland was, of old, extremely subject to the influence of earthquakes within historical times.

5th. By comparing our ancient with our modern records, we have a means—wanting in most, if not all, countries besides—of noting with approximate accuracy the increase or decrease of seismical energy in a given area.

When the great convulsions, tailing off, gradually diminished in frequency and intensity, the principal physical changes which afterwards took place were those attributable to common causes usually seen in operation. In some cases, by the gradual silting up of straits and channels, and by the growth of bog, islands have been united to the mainland. Instances may be found in the case of Malin, formerly insulated; of Innishowen, formerly insulated; of the Isle of Doagh, and of the Isle of Inch (both in Lough Swilly); of Horn Head, the Isle of Derry, and of several islets on the north-west coast. According to the observations of Professors Sullivan and O'Reilly, the Hill of Howth was also formerly insulated.

Alterations in the physical geography of the country have also taken place by the obliteration of lakes, wrought by deposit of alluvium, by evaporation, or by migration of the waters of the lake rupturing their boundary (of which America offers recent instances).

The following are the names of the lakes whose former existence I have traced, and whose places are now occupied by bog or dry land: Loch Burran, now called "Loughaverra," in the parish of Ballintay, Antrim; Loch Cre, the island of which now occupies the centre of a bog in the townland of Monahinsha (bog of the island), in the parish of Corbally, Tipperary; Lough Foyle, now represented by a river (still called "Lough Foyle"), extending between Strabane and Derry; Loch Gabair, now Logore, in Meath; Loch Gair, now Lough Gur, Co. Limerick, still a lake, but of diminished size, as its island has become attached to the mainland; Loch Laeghaire, south of Strabane. These lakes became effaced, quietly, by evaporation and deposit; others burst bounds and ran off. Thus the Four Masters, and Nennius, relate that, A. D. 848, Loch Laeigh, in Mayo, "migrated," and "ran off into the sea." Again, A. D. 1054, Lough Syorun, in Cavan, "migrated in the end of the night of the Festival of Michael, and went into the river Feabail, which was a great wonder to all." Finally, having searched in vain for a Loch Monann, mentioned in the Annals, A. D. 1544, I discovered a townland of that name on the Escheatment map, 1609. The lake no longer exists, but the ravine known as Strabane glen, which extends from the townland (whose ancient name is now obsolete), appears to furnish the channel by which it, also, "migrated."

III.—On a Cause of the Buoyancy of Bodies of a Greater Density than Water. By George Sigerson, M. D., Ch. M., F. L. S.

[Read June 23, 1873.]

In considering the phenomena attendant on the buoyancy of bodies of a greater density than water, observers appear to have confined their attention exclusively to the relations of those bodies and the fluid on which they were placed. In other words, they limit their observation to the visible substances. From certain facts which have come under my notice, the results of some experiments, it seems to me that a distinct and important part is played, in the causation of such phenomena, by an agent hitherto unsuspected, because invisible to the eye, namely, the atmospheric air.

It is known that when small bodies, such as needles, grains of sand, seeds, and so forth, are placed gently on the surface of water, they will float, although their density is greater than water.

On examination, it is found that they rest partly in the water, partly in a depression of the surface, which surrounds them with a convex ridge. To explain their buoyancy in such circumstances, reference has been made to the viscosity of the fluid, or tenacity of molecular cohesion, to a repulsive force supposed to be exerted in some way by the floating body which repels the water, and to capillarity. When we admit the viscosity, for whatever it is worth, it is found insufficient to account for the buoyancy; as for the others, they are explanations which require themselves to be explained.

What is the actual physical condition of the floating object?

Firstly: It is partially immersed in water. It loses thus part of its weight, equal to the weight of liquid which it displaces. Two forces are recognised in action: its weight acting vertically downwards, and the resultant of fluid pressures acting vertically upwards. There is, I allege, another force. Secondly: The body is also, be it remarked, not only partially immersed in water—it is also partially immersed in air. Now, to the forces which come into action through *this* medium, in co-operation with those described, I attribute the buoyancy of such bodies.

The adhesion of the air to a body surrounds it, as it were, with an atmosphere of its own. This film of air remains in intimate contact with it until replaced, as it may be, by some other medium of greater adhesive power. To describe this air-wetting a word is required, if aeration will not serve: it seems, however, a condition perfectly analogous to hydration or water-wetting. To a body wetted in water a layer of water attaches with an adhesive force greater than the force of cohesion which keeps the molecules of water together; for, if we raise such a body out of the fluid there is rupture of this force, as a film of water will still adhere strongly to the removed body. The adhesion of air to an aerated, air-wetted, or (as commonly said) dry body is likewise strong, in many cases, though not so open to remark. To a large number of bodies, which come easily under our notice, water adheres more vigorously than air; they are readily water-wetted. But there are also some to which the air appears to adhere with greater tenacity.

When an aerated body is placed on the surface of water, its atmosphere, that is to say, the film of air which surrounds it, tends to increase its volume without increasing its weight. Being much lighter than water, the adhering air will, therefore, co-operate with other causes to prevent the body from sinking and to keep it buoyant, as long as the force of air-adhesion endures.

In order to demonstrate that air-adhesion supplies a force potent enough to act in the manner alleged, it is only necessary to take some small bodies, whose density in relation to size shall not be very great, but amply sufficient to cause sinking when water-wetted. In experimenting, I have found it most convenient to use seeds, taking different kinds and sizes, generally round in form, such as the seeds of Everlasting Pea (*Lathyrus latifolius*), of Sweet Pea (*Lathyrus odoratus*), of mustard, turnips, &c. If water-wetted, any of these objects will sink at once, but when placed on the surface, dry (or aerated), they float. There they illustrate all the phenomena of "capillarity" and "attraction" known in such cases.

Whilst the under surface and sides have become water-wetted, there is a dry patch above—in other words, to a portion of the upper surface the air still adheres. A comparatively smart blow may be given here, without causing such a body to sink—it will go down a little and rebound; but if it be lightly touched (say a turnip-seed by a flat-ended pencil), so that the water cover it, it sinks at once. That is to say—the air-adhesion has been broken, the complementary cause of its buoyancy.

If we now take some dry or aerated seeds and drop them into the water from various distances, say about a foot high, the force of the air-adhesion becomes strikingly and beautifully manifested. It will be immediately remarked that numbers of the seeds as they sink in the water have small globes of air adhering to them. We may have the following cases occurring:—

1. The body, falling from a height, may retain a globule of air adhering to it, insufficient to counteract its own weight and the water-pressure. It remains, therefore, at the bottom, and with it remains the air-globule. The force of adhesion here manifested is stronger than that which solicits the air to ascend to the surface.

2. The body may carry down with it a globule sufficiently large to raise it from the bottom, assisted perhaps by the rebound, if the shock be not strong enough to sever the adhesion and set the globule free.

3. The body may take with it adhering air sufficient to serve as counterpoise (if I may use the words) to its own weight in water, and thus it may float completely immersed in the water, surmounted by an air-globule.

4. The amount of air adhering may be so great as to prevent the complete descent of the body, to hinder it from diving much below the surface, and to rapidly draw it up again to the surface. In such a case, the adhesion of the air to the object is evidently strong enough to completely resist the weight of the object in water, and to partially resist the force acquired by a fall from a distance, relatively considerable.

The air-adhesion may be broken in, at least, three ways. First, by the blow the object receives on striking the surface in its descent, so that it may go down without any globule, or if the effect be partial, with a small one. Second, by the blow received on reaching the bottom. Third, by the shock when, rising to the surface, the air globule suddenly expands. On account of the narrowness of the base of connexion, in some cases, the adhesion may be quietly severed, by water-pressure.

In cases where a body is quite buoyant in the water, on account of the attached globule, it may be readily shown that the base of connexion forms an adhesion area large enough to sustain this body at the surface, when the upper air shall replace the globule. This is demonstrated, as in case 2, by gently elevating the body to the surface, and allowing the globule to open into the upper air: or, by observing, as in cases 3 and 4, the ascent of bodies drawn up by their globules to the surface, where, if the shock of the expansion of the globule do not sever the adhesion, they will float. In such cases, the area of aerated space remaining the same, the adhesion of the upper air now manifestly sustains the body in a buoyant state.

In this condition buoyant bodies, whose density is greater than water, present themselves usually to observers. From the facts related, it follows that they are sustained in this position, partly by the adhesion of the atmospheric air.

The incidents of this demonstration suggest some remarks and inferences. When we withdraw a glass rod or a wetted body from water, the drop which adheres shows that in such cases the force of adhesion between the liquid and solid is greater than the force of cohesion between the molecules of the liquid. Conversely, when we let pass an aerated body from the air into the liquid, the globule or drop of air which adheres to it, proves that, in such cases, the force of adhesion between the gas and the solid is greater than the force of cohesion between the molecules of the gas. We have seen that it is also strong enough, in certain cases, to sustain a weight as great as, or greater than, the weight of a given body, *minus* the weight of the volume of water displaced, and that it is potent enough to resist the action of the forces which, when a body is let fall from a height into water, tend to separate globule and body, sending the former upwards and the latter down.

The force of adhesion between air and solid is, therefore, for many reasons, a very tangible and noteworthy force, which cannot be eliminated from consideration, in such and similar problems, without inaccuracy.

This being so, it may become necessary to revise certain definitions or statements of laws in physics, in order that the presence of this force may be recognised where it exists. Thus, it is mentioned that a floating body is acted on by two forces—its weight, and the resultant of fluid pressure. To this it may be necessary to add, that a third force, adhesion of air, exists, and becomes a perceptible agent in the case of small floating bodies.

Again, in the curving of liquids in contact with solids, the presence of air is altogether unrecognised, and only the forces acting through the visible media are mentioned. Thus we are told that when a solid is placed in a liquid which wets it, the liquid, as if not subject to the law of gravitation, rises against the side of the solid and becomes concave. It is added that where the solid is not wetted by the fluid, the latter is depressed and becomes convex. Now, it appears to me, from the foregoing facts, that this should be re-stated in the following manner: When an aerated solid is placed in a liquid whose adhesive power is greater than the adhesive power of air, as regards such solid, the air is partially displaced, the fluid becoming concave and the air convex. But when an aerated solid is placed in a liquid whose adhesive power is less than the adhesive power of air, as regards such solid, then the water is partially displaced by the air and becomes convex, whilst the latter grows concave. The concave, in either case, bounds the outward side of a wedge of advancing substance, whose inner side is applied to the solid.

It follows that it would probably be well to modify the manner in which the first law of Gay Lussac is expressed, in order to recognise the presence of air-adhesion as a power. As it stands, the law is: "When a capillary tube is placed in a liquid, the liquid is raised or depressed according as it does or does not moisten the tube." I would read it thus: "When a capillary tube is placed in a liquid, the liquid is raised or depressed according as its adhesive power is greater or less than that of the air."

These suggestions are offered, with diffidence, to the consideration of physicists, as there may, in such cases, be forces operative which have not yet come under review. But, lest I should be supposed to have overlooked the obvious objection that Gay Lussac's law is said to hold good in vacuo, and therefore in the absence of air, I must add that it is confessed that the air-pump gives no absolute vacuum.

The air becomes exceedingly rarified, but a perceptible quantity is left. And, when it is remembered that, from the facts now experimentally demonstrated, it was shown that the adhesion of air to a solid, in a given case, is greater than the adhesion of air-molecules between themselves, it will be admitted that the instruments used in an air-pump may be covered with an adhering film of air, until displaced by water, operative in causing the phenomena recorded.

IV.—On some general Formulæ for the Solution of Algebraical Equations of the Third Degree, &c. By J. R. Young, formerly Professor of Mathematics in Belfast College.

[Read May 25, 1874.]

A general formula for the solution of any equation of the *second* degree is readily obtained by means of the well-known expedient of *completing the square*. I am not aware that any algebraist, as yet, has investigated a like general formula for the solution of an equation of the *third* degree; that is, by the similar preliminary expedient of *completing the cube*. It is the main purpose of the present Paper to establish such a general formula; previously, however, to which, it will be necessary to dispose of the two following special cases, that is to say, to prove that—

(1) Whenever in an equation of the third degree,

$$A_3x^3 + A_2x^2 + A_1x + A_0 = 0,$$

either the first triad of the coefficients, A_3, A_2, A_1, or the second triad, A_2, A_1, A_0, furnishes the relation of equality

$$3A_3 A_1 = A_2^2, \text{ or } 3A_2 A_0 = A_1^2 \ldots . \qquad [1]$$

the first member of the equation can easily be converted into a complete cube, and thence a general expression for the root x be deduced.

1. Let it be the first of the conditions [1] which has place, and let a quantity k be so determined that, by the addition of k to A_0, the *second* condition also may be satisfied; namely, the condition

$$3A_2 (A_0 + k) = A_1^2;$$

in order to which, the value of k must evidently be

$$k = \frac{A_1^2}{3A_2} - A_0,$$

so that this quantity being added, there results the equation

$$A_3x^3 + A_2x^2 + A_1x + \frac{A_1^2}{3A_2} = k;$$

and, consequently, dividing by A_3, and taking account of the stipulated condition, we shall have

$$x^3 + 3\frac{A_1}{A_2}x^2 + 3\left(\frac{A_1}{A_2}\right)^2 x + \left(\frac{A_1}{A_2}\right)^3 = \frac{k}{A_3},$$

the first member of which equation is a complete cube. Hence,

$$\left(x+\frac{A_1}{A_2}\right)^3=\frac{k}{A_3}, \therefore x+\frac{A_1}{A_2}=\sqrt[3]{\frac{k}{A_3}}:$$

$$\therefore x=-\frac{A_1}{A_2}+\sqrt[3]{\frac{k}{A_3}}=-\frac{A_1}{A_2}+\sqrt[3]{\left(\frac{A_1^2}{3A_2A_3}-\frac{A_0}{A_3}\right)};$$

or,

$$x=-\frac{A_1}{A_2}+\sqrt[3]{\frac{A_1^2-3A_0A_2}{3A_2A_3}}\ldots. \qquad [2]$$

2. Suppose now that it is the *second* of the conditions [1] that is satisfied; then the first condition also will be satisfied, provided a quantity p be so determined, as that, when it is added to A_3, the condition

$$3(A_3+p)A_1=A_2^2$$

may be satisfied; that is to say, provided we make

$$p=\frac{A_2^2}{3A_1}-A_3;$$

since this value of p, when added to the coefficient of x^3, will convert the proposed equation into

$$\frac{A_2^2}{3A_1}x^3+A_2x^2+A_1x+A_0=px^3.$$

Hence, multiplying by $\frac{3A_1}{A_2^2}$, and observing from the stipulated condition [1] that A_0 is the same as $\frac{A_1^2}{3A_2}$, we have

$$x^3+3\frac{A_1}{A_2}x^2+3\left(\frac{A_1}{A_2}\right)^2x+\left(\frac{A_1}{A_2}\right)^3=3\frac{A_1}{A_2^2}px^3;$$

the first member of which equation is a complete cube. Consequently,

$$\left(x+\frac{A_1}{A_2}\right)^3=3\frac{A_1}{A_2^2}px^3, \therefore x+\frac{A_1}{A_2}=x\sqrt[3]{3\frac{A_1}{A_2^2}p}:$$

$$\therefore x=-\frac{A_1}{A_2}\div\left(1-\sqrt[3]{3\frac{A_1}{A_2^2}p}\right)=-\frac{A_1}{A_2}\div\left\{1-\sqrt[3]{\left(1-\frac{3A_1A_3}{A_2^2}\right)}\right\};$$

or,

$$x=-\frac{A_1}{A_2}\div\left\{1-\sqrt[3]{\frac{A_2^2-3A_1A_3}{A_2^2}}\right\}\ldots. \qquad [3]$$

(2) I have shown in a formercommunication to the Academy "Proceedings," vol. x., p. 373), that if any cubic equation be represented by $P = O$, and the first and second functions derived from P, by Q and P' respectively, the equation $Q^2 - 3PP' = O$ will always be a *quadratic* equation. Let one of the roots of this equation—either root indifferently —be represented by r; and let each root of the proposed cubic equation

$$P = A_3x^3 + A_2x^2 + A_1x + A_0 = O$$

be diminished by r. The resulting transformed equation will be

$$A_3x'^3 + (3A_3r + A_2)\,x'^2 + (3A_3r^2 + 2A_2r + A_1)\,x' + A_3r^3 + A_2r^2 + A_1r + A_0 = O,$$

the second triad of coefficients of which fulfils the second of the two conditions [1]; and, consequently, by the formula [3], we have for x' the expression

$$x' = -\frac{3A_3r^2 + 2A_2r + A_1}{3A_3r + A_2} \div \left\{1 - \sqrt[3]{\frac{A_2^2 - 3A_1A_3}{(3A_3r + A_2)^2}}\right\}.$$

Therefore, multiplying numerator and denominator of the fraction under the radical sign by $3A_3r + A_2$, and remembering that $x = r + x'$, we shall have for x, the expression,

$$x = r - \frac{3A_3r^2 + 2A_2r + A_1}{3A_3r + A_2 - \sqrt[3]{\{(A_2^2 - 3A_1A_3)(3A_3r + A_2)\}}}. \qquad (4)$$

And this is a general symbolical formula for the three roots of the cubic equation $P = O$.

(3). Whenever r, determined as already explained, is *real*, we may be certain that only one of the three roots of the cubic is a real root, since a cube root has but one real value;* and this real root the formula (4) will enable us to determine, by introducing into that formula the *real* cube root only of the number under the sign $\sqrt[3]{\ }$; and the two imaginary roots of the equation will be expressed by introducing into the formula the two imaginary cube roots of the number under the sign $\sqrt[3]{\ }$, after the real cube root of that number has been determined. But whenever r is imaginary, then, although we know, in that case,

* And in this manner is the truth of the *second* of the general properties, noticed at Article 5 following, otherwise proved: the *first* of those properties showing that, if r be imaginary, the above expression for x, notwithstanding its being then so encumbered with imaginary quantities, must have all its values real values. Moreover, this *first* of the properties at (5) may also be deduced from the general formula above; for since, as just seen, two roots of the equation must be imaginary whenever r is *real*, the roots must all be real when, and only when, r is imaginary.

that all the roots of the cubic equation must be real roots ("Proceedings," vol. x., page 374); yet we have no means of extricating these real values from the imaginary forms under which they lie concealed. (See NOTE at the end of this Paper).

The more restricted formula of Cardan is in the like predicament. For the application of this formula, the equation must be reduced to the form

$$x^3 + A_1 x + A_0 = 0.$$

The expression for x, as furnished by the formula (4), when the *proposed* equation takes this more simple form, is

$$x = r - \frac{3r^2 + A_1}{3r - \sqrt[3]{-9A_1 r}} = r\,\frac{\sqrt[3]{-9A_1 r} + A_1}{\sqrt[3]{-9A_1 r} - 3r}. \qquad (5)$$

This expression is "irreducible" under precisely the same circumstances that the expression of Cardan is; namely, whenever $27A_0^2 + 4A_1^3 < 0$; or, which is the same thing, whenever

$$\left(-\frac{A_1}{3}\right)^3 > \left(\frac{A_0}{2}\right)^2.$$

This may be easily proved by deducing the equation $Q^2 - 3PP' = 0$, and thence the expression for r, from the incomplete cubic equation $P = 0$: thus:

$$P = x^3 + A_1 x + A_0 = 11$$
$$Q = 3x^2 + A_1$$
$$P' = 3x,$$

from which we get the quadratic equation,

$$Q^2 - 3PP' = -3A_1 x^2 - 9A_0 x + A_1^2 = 0;$$

$$\therefore \quad x = r = \frac{-9A_0 \pm \sqrt{\{(9A_0)^2 + 12A_1^3\}}}{6A_1},$$

showing that r is imaginary, and, therefore, all the roots of $P = 0$ real whenever, and *only* whenever

$$81A_0^2 + 12A_1^3 < 0; \text{ or whenever } 27A_0^2 + 4A_1^3 < 0;$$

under which condition the formula (5), like that of Cardan, is irreducible to a finite numerical expression for the real roots of the equation $R = 0$, which shall be unencumbered with imaginary quantities. [It is obvious that the foregoing condition can never be satisfied unless the coefficient A_1 is negative.]

Whether, in the *reducible* cases of the equation $x^3 + A_1x + A_0 = 0$, that is, in the cases in which $27A_0^2 + 4A_1^3$ is *not* less than zero, the formula [5] may, or may not, advantageously replace the old formula of Cardan, must be left for the discrimination of algebraists to determine. Few persons, however, are likely to prefer a *formula* to the method of continuous approximation, whenever the *numerical values* of the roots of an equation of higher degree than the second degree are the only objects of search.

(4.) Whenever it happens, in this case of an incomplete cubic equation, that $(9A_0)^2 + 12A_1^3$, or, which is the same thing, that $27A_0^2 + 4A_1^3$ is *zero*, the two values of r, as expressed in the foregoing formula, will be *equal* values; and, as already proved in the Paper before referred to, these are also two roots of the cubic $P = 0$; hence, whenever this condition has place, the incomplete cubic equation has a pair of equal roots, each of these being,

$$x = -\frac{9A_0}{6A_1} = -\frac{3A_0}{2A_1}.$$

It may be well to observe here that the case of *equal* roots in any cubic equation, is excluded from the general investigation at article (2). The transformed equation, in x', of which the first three terms are

$$A_3x'^3 + (3A_3r + A_2)x'^2 + (3A_3r^2 + 2A_2r + A_1)x',$$

is there considered to have a significant coefficient for its third term; since if the expression

$$3A_3r^2 + 2A_2r + A_1$$

were zero, the first member of this transformed equation could not be made a complete cube by merely modifying the coefficient of x'^3, as, in the investigation alluded to, is assumed to be practicable.

When the *indicating quadratic* ($Q^2 - 3PP' = 0$), as we may call it, has two equal roots, and, *therefore*, the cubic $P = 0$ has the same two equal roots, the above-written coefficient must be zero; in which case the transformed equation becomes simply

$$A_3x'^3 + (3A_3r + A_2)x'^2 = 0,$$

of which the three roots are

$$x' = 0,\ x' = 0,\ x' = -\frac{3A_3r + A_2}{A_3};$$

and, therefore, those of the original equation are

$$x = r,\ x = r,\ x = -\frac{3A_3r + A_2}{A_3} = -\frac{2A_3r + A_2}{A_3},$$

the sum of which roots is

$$2r - -\frac{2A_3r + A_2}{A_3} = -\frac{A_2}{A_3},$$

as we know it ought to be. In the case of the incomplete cubic, considered above, in which $A_3 = 1$, and $A_2 = 0$, this sum is, of course, zero.

(5.) It was sufficiently shown in my former Paper (Article 33), that, if any cubic equation $P = 0$, be written in the form,

$$P = (ax^2 + bx + c)(x + p) = 0,$$

in which a, b, c, and p, have any real values whatever, and that the quadratic equation $Q^2 - 3PP' = 0$, be

$$Ax^2 + Bx + C = 0,$$

the following relations necessarily have place; namely,

$$\text{If } B^2 < 4AC, \text{ then } b^2 > 4ac;$$
$$\text{,, } B^2 > 4AC, \text{ ,, } b^2 < 4ac;$$

and conversely; from which relations it follows that

$$\text{If } B^2 = 4AC, \text{ then } b^2 = 4ac;$$
$$\text{,, } b^2 = 4ac, \text{ ,, } B^2 = 4AC.$$

The determination of the indicating quadratic,

$$Q^2 - 3PP' = Ax^2 + Bx + C = 0,$$

in any individual instance, involves but very little calculation; because, since we know that the first two terms of Q^2 are always the same as the first two terms of $3PP'$, we need not take the trouble to compute them; it is sufficient that we preserve, in the multiplications, only the terms beyond the first two terms of each product.

In order to illustrate this by an example, let the proposed equation be

$$P = x^3 - 4x^2 + 3x + 2 = 0$$
$$\therefore Q = 3x^2 - 8x + 3$$
$$P' = 3x - 4$$

$$\begin{array}{c} 3x^2 - 8x + 3 \\ 3x^2 - 8x + 3 \\ \hline 18x^2 + 64x^2 - 48x + 9 \end{array}, \quad \begin{array}{c} x^3 - 4x^2 + 3x + 2 \\ 3x - 4 \\ \hline 9x^2 + 16x^2 - 12x + 6x - 8, \times 3 \end{array}$$

or

$$\begin{aligned} & 82x^2 - 48x + 9 \\ & = 75x^2 - 18x - 24 = 3(25x^2 - 6x - 8) \\ \therefore Q^2 - 3PP' & = \underline{7x^2 - 30x + 33} = 0, \end{aligned}$$

the indicating quadratic.

And since the roots of this are seen to be imaginary, the equation *indicates* a pair of real roots in the cubic $P = 0$; and, consequently, that all the roots are real.

(6.) But the indicating quadratic may always be arrived at in another way. This other method of proceeding consists in extracting the square root of the product $3PP'$; taking care, however, that the successive terms of the root be the successive terms of the quadratic function Q.* Under this condition, the *remainder*, at which we shall arrive, when taken with changed signs, and equated to zero, will always be the indicating quadratic. Thus, taking the example just given, where the complete product $3PP'$ is

$$3PP' = 9x^4 - 48x^3 + 75x^2 - 18x - 24,$$

and extracting the square root in such way that the terms put one after another, in the root-place, may be $3x^2 - 8x + 3$; we shall find the remainder, at the end of the operation, to be $-7x^2 + 30x - 33$. This remainder, after changing the signs of its terms, will be $7x^2 - 30x + 33$; which, equated to zero, will be the indicating quadratic.

That the indicating quadratic may always be arrived at in this manner will appear from considering that if we put $q = 0$ to denote this quadratic, that is, if $Q^2 - 3PP' = q$, it will follow that $3PP' = Q^2 - q$. But in the square root operation described above, $3PP'$ is equal to Q^2 *plus* the remainder; consequently, q is this remainder taken with changed signs.

Since all the roots of the foregoing cubic equation are shown by the indicating quadratic to be *real* roots, we know that the two roots of the *derived* quadratic equation, $Q = 3x^2 - 8x + 3 = 0$, must be *separators* of those three roots; the middle one of the three lying between the two real roots of $Q = 0$. In order to the actual determination of the numerical values of the three roots, the shortest way of proceeding

* There is, however, no necessity to revert to the expression Q for the first two of the root terms; these same two terms may be arrived at by following the ordinary rule for the extraction of the square root. Q need be referred to only for the *third* term—the absolute number.

will be this. Develope the middle root by continuous approximation: we shall thus arrive at a *quadratic* equation, the roots of which, when each of them is increased by the root previously developed, will be the other two roots of the proposed cubic.

(7.) When each triad of the coefficients of a cubic equation fails to satisfy the condition of imaginary roots, and that the roots r_1, r_2, of the indicating quadratic equation $Q^2 - 3PP' = 0$, are real and unequal, the roots of the derived quadratic $Q = 0$ will necessarily be real roots. One of these roots, and one only, will be situated in the interval $[r_1, r_2]$; and if the roots of the cubic be each of them diminished by that root of $Q = 0$, the third coefficient of the transformed equation will vanish between like signs.

For r_1, r_2, are either both positive or both negative, inasmuch as that the first and third terms of the quadratic $Q^2 - 3PP' = 0$ are then both positive;* and, therefore, if r_1 be that one of these two roots which is the nearer to $-\infty$, the quadratic expression $Q^2 - 3PP'$ will be positive for every value of x, from the value $x = -\infty$ up to the value $x = r_1$; and also for every value of x, from the value $x = +\infty$ down to the value $x = r_2$. And since the expression changes sign immediately after the passage of a root, and that the changed sign remains permanent till the other root passes, it follows that for every value of x, within the limits $[r_1, r_2]$, the expression $Q^2 - 3PP'$ must be negative; whilst for every value of x, *outside* those limits, it must be positive. This is the same as saying that for every value of x, within the limits $[r_1, r_2]$, the condition of imaginary roots is satisfied, whilst for every value of x, outside those limits, the condition fails to be satisfied. At either of the limits, that is, for $x = r_1$, or for $x = r_2$, the condition of imaginarity is still satisfied; since, for either of these values of x, $3PP' = Q^2$. But when the roots r_1, r_2, of the indicating quadratic are *equal roots*, then we know that these same equal roots belong also to the proposed cubic $P = 0$—the imaginarity disappearing with the disappearance of inequality between the roots $[r_1, r_2]$.

It is impossible, therefore, that Q can vanish between like signs of P and P' *outside* the limits $[r_1, r_2]$, seeing that if Q could so vanish, $Q^2 - 3PP'$, for the value of x which causes Q thus to vanish, would be *negative*.

But *one* of the two roots of $Q = 0$ *must* cause Q to vanish between like signs of P and P'; consequently, *this* root of $Q = 0$ must lie *between* r_1 and r_2.

It is plain that Q cannot vanish a *second* time between like signs of P and P'; since such second evanescence would imply a second pair of imaginary roots in an equation of only the third degree. Hence, the other root of $Q = 0$ must cause Q to vanish between *unlike* signs of P and P'; so that when this evanescence takes place, the expression $Q^2 - 3PP'$ must be positive.

* See the expression marked (1) at page 473 of the former Paper.

(8.) If we agree to call that particular root of $Q=0$, which lies in the interval $[r_1, r_2]$, the *indicator* of the two imaginary roots of the cubic equation $P=0$, we may infer, from what is shown above, that when the two roots of the indicating quadratic are real, if they be positive (they must always both have the same sign), the *indicator* is a positive number; and if they are negative, the indicator is a negative number; that is to say, the region in which the real roots of the indicating quadratic lie is the region in which the indicator itself lies. And we have seen that that root of the derived quadratic equation $Q=0$, which is the indicator, is the *only* one of the two roots of that equation which lies between the roots r_1, r_2 of the equation $Q^2-3PP'=0$, the other root of $Q=0$ being excluded from that interval.

The *real* root, however, of the proposed cubic equation $P=0$ *must* lie outside the interval $[r_1, r_2]$; for, as shown above, every value of x, *within* this interval, causes the expression Q^2-3PP' to be *negative;* whereas the value of x, which satisfies the condition $P=0$, reduces that expression to Q^2, which is *positive;* and, for a similar reason, the root of the simple equation $P'=0$ must lie without the interval.

That the real root of the cubic equation lies *without* the interval $[r_1, r_2]$ is a conclusion that might have been immediately deduced from the foregoing truth; namely, that that root of $Q=0$, which is not the indicator, does itself lie without the interval. For, since this root separates the real root of the cubic from the imaginary pair, or rather from the *indicator* of that pair, the real root of $P=0$ must occupy a place more remote from the interval $[r_1, r_2]$ than is the place of that root of $Q=0$, which is not the indicator of the imaginary pair.

(9.) It thus appears that, without any preliminary analysis of the cubic equation $P=0$, we can always ascertain, from an examination of the quadratic equation $Q^2-3PP'=0$—

First, whether the equation $P=0$ has a pair of imaginary roots or not.

Second; if it *have* imaginary roots, *which* of the two roots of the derived quadratic, $Q=0$, it is that is the *indicator* of the pair; it is that one which lies between the two roots of $Q^2-3PP'=0$; and only one of the two can so lie.

And, thirdly, we learn that the real root of the cubic always lies *outside* the interval between the two roots of the equation last mentioned; and from thus knowing the interval from which it is excluded, the first figure of it becomes the more readily determinable, whenever all three of the roots are indicated, by the signs of the terms of the equation, in one and the same region.

We may further observe here, that whenever we seek to determine the character of a pair of doubtful roots in a cubic equation $P=0$ (and which roots are indicated in an interval comprehending also a real root of $Q=0$), by the process of continuous approximation, we may be sure, if the roots be imaginary, that the indieation of imaginarity will not be arrived at till the approximating number reaches one or other of the values r_1, or r_2; after arriving at which, the condition of imaginarity will be satisfied, but not before; and that the condition will continue to be satisfied for every subsequent transformation, throughout the interval $[r_1, r_2]$, but not after that interval has been passed over.

It will have been noticed that the foregoing discussion concerns those cubic equations only of which the given coefficients do not themselves supply the required information as to the character of the roots; that is to say, those equations only in which neither triad of the coefficients satisfies the condition of imaginary roots.

(10.) In the case in which the *first* triad of the coefficients of the cubic equation $P=0$ satisfies the condition of imaginarity, the roots of the derived quadratic equation, $Q=0$, will be imaginary; and the root of the simple equation, $P'=0$, will then be the indicator. But if the condition of imaginarity be satisfied by the *second* triad of the coefficients, and not by the first also—under which circumstances $Q=0$ will have real roots—the roots of the indicating quadratic will be real roots; and, as already noticed (Art. 6), one of these roots will be positive, and the other negative; and, as before, the condition of imaginarity will have place throughout the interval between those roots, and will fail to have place for all values outside that interval. But if both triads of the coefficients satisfy the condition of imaginarity, then the first and last terms of the indicating quadratic, the terms

$$(A_2^2 - 3A_1A_3)x^2, \text{ and } (A_1^2 - 3A_0A_2),$$

will each be preceded by the negative sign; so that a pair of imaginary roots in the equation $P=0$ would be implied, even should the roots of the indicating quadratic, $Q^2 - 3PP'=0$, be themselves imaginary; because, then, the first member of this quadratic would be *always negative;* that is to say, the quadratic expression, $3PP' - Q^2$, would be positive for *every* real value of x. As before, the indicator of the pair of imaginary roots would be the root of the simple equation $P'=0$, this root being the value of x, for which a derived function vanishes between like signs of the two adjacent derived functions.

(11.) It is well known that each of the two roots of an equation of the second degree, whenever these roots are unequal, always consists of two distinct parts—the one being a rational number, and the other part being a number, either positive or negative, under the radical sign, with, usually, a real factor prefixed to the radical quantity; the rational part of each root is always the root of the derived simple equation.

But when the quadratic is raised to an equation of the third degree, by the introduction of a new simple factor, it is not the case that a root of the equation of the second degree, derived from this cubic equation, will be the rational part of each of the two roots of the quadratic equation which enters into the composition of the cubic. For, let $ax^2 + bx + c = 0$ represent any quadratic equation, then the derived simple equation will be $2ax + b = 0$; and if

$$P = (ax^2 + bx + c)(x + p),$$

then,

$$Q = ax^2 + bx + c + (2ax + b)(x + p).$$

Now, if the value of x, which makes $2ax + b = 0$, namely, the value $x = -\frac{b}{2a}$, makes also $Q = 0$, then we must have for that same value of x

$$ax^2 + bx + c = 0,$$

which can be the case only when this latter equation has *equal roots;* that is to say, only when the first member of it is a complete square; under which circumstance the equation $P = 0$ must have two equal roots. Hence, that root of $Q = 0$, which is the *indicator* of a pair of *imaginary* roots in the cubic equation $P = 0$,—the value of x, that is, which causes Q to vanish between like signs of P and P'—can never be equal to the real part of the imaginary pair thus indicated.

[In an equation of degree higher than the third degree, *it is possible,* when the first member of it has a quadratic factor, the roots of which are imaginary, that a root of the first derived equation may be equal to the real part of the imaginary pair; but this can happen only under peculiar circumstances. Let $Ff = 0$ be an equation of degree higher than the third degree, and of which f is a quadratic factor, such that the roots of $f = 0$ are imaginary. Then, writing F^1, f^1, for the first derivees of Ff, the first derivee of Ff will be

$$Ff^1 + fF^1;$$

and if this be zero, for the value of x, which is the root of the simple equation $f^1 = 0$, then F^1 must be zero also; since f is *not* zero for that value of x, but is necessarily a positive number. Hence, the value of x, which satisfies the equation $f^1 = 0$, cannot possibly also satisfy the derived equation

$$F^1 f^1 + fF^1 = 0,$$

unless, under the special condition that x is a root of $F^1 = 0$, as well as a root of $f^1 = 0$].

(12.) The conclusion in the last Article, namely, that the value of x, which causes Q to vanish between like signs of P and P', can never be equal to the real part of the pair of imaginary roots indicated, may be easily generalized; and the more comprehensive proposition be stated thus:

If two roots, whether real or imaginary, of a cubic equation be expressed in the form $p+q$ (and any two numbers may be so expressed),* it is impossible that, by diminishing the three roots, each by p, the resulting equation can ever be of the form

$$x^3 + A_2 x^2 + 0x + A_0 = 0.$$

For, putting a for the diminished third root of the equation, the three roots of the transformed equation will be

$$a + q - q;$$

and, therefore, the coefficient of x, in that transformed equation, will be

$$+ aq - aq - aq^2 = - q^2;$$

and, consequently, this coefficient cannot be zero, so long as q is a significant quantity—whether real or imaginary.

[If q be zero, that is, if the cubic equation have two roots, each equal to p, then, of course, not only is the coefficient of x, in the transformation by p zero, but the absolute term in that transformation is also zero].

(13.) It is deserving of remark, finally, that—

If *the same pair* of imaginary roots enter into two different equations, that pair may be indicated, by the signs of the coefficients of one of those equations, as belonging to the *positive* region of the roots, and by the signs of the coefficients of the other equation, as belonging to the *negative* region.

For, first, let there be the equation

$$(x^2 + a^2)(x + b) = x^3 + bx^2 + ax^2 + a^2 b = 0 \ldots [1];$$

and, next, the equation

$$(x^2 + a^2)(x - c) = x^3 - cx^2 + a^2 x - a^2 c = 0 \ldots [2],$$

in which equations b and c are both positive numbers. Then the three roots of [1] will all belong to the negative region of the roots, and the three roots of [2] will all belong to the positive region; and yet the pair of imaginary roots, namely, the two roots of the equation

$$x^2 + a^2 = 0$$

are the same in both equations.

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* For r, r', being any two numbers, if we put p for $\frac{1}{2}r + \frac{1}{2}r'$, and q for $\frac{1}{2}r - \frac{1}{2}r'$, we shall have $r = p + q$, and $r' = p - q$.

Let now each of the roots of the equations [1] and [2] be diminished by any positive number δ; then the signs of the terms in the transformed equation deduced from [1] will all be positive; but in the transformed equation deduced from [2] it is plain that δ may be sufficiently small to cause the signs of the terms to be alternately positive and negative, as in the equation [2] itself. The same pair of imaginary roots must, however, enter into *both* of the transformed equations; though, in the first of these, the signs of the terms imply that the imaginary roots belong to the negative region; and in the second, the signs imply that these same roots belong to the positive region.

We thus see that the region in which a pair of imaginary roots is indicated by the signs of the terms of an equation, supplies no sufficient clue as to whether the real part, common to the two imaginary roots, is positive or negative, whenever the equation is of a higher degree than the second degree. In a *quadratic* equation, of which the roots are imaginary, the case is different; the sign of the real part is always indicated; it is the opposite of that prefixed to the coefficient of the middle term, whenever such middle term is present. If the middle term be absent, the real part of each imaginary root will then, of course, be zero; but in a *complete* quadratic equation, not only is the region to which each of the two roots belongs indicated—whether these roots be real or imaginary—but the part of the pair of roots which is free from the radical sign is also indicated; it is always half the coefficient of the middle term, taken with changed sign—the coefficient of the first term being unity. In other words, as before stated, the part which precedes the radical sign is always the root of the simple equation derived from the quadratic, whether the other part of the expression for the pair of roots of the quadratic be real or imaginary.

In the foregoing discussion, I have frequently spoken of a pair of imaginary roots as being in, or belonging to, the positive region, or the negative region. This phraseology, though in conformity with general usage, is objectionable. An imaginary quantity cannot have any place in a series of positive numbers, nor yet in a series of negative numbers; because it is entirely out of the range of *every* series of *numbers*. The phrase should be taken to mean merely that *the indicator* of the pair is in the positive, or in the negative region, as the case may be; or, still more explicitly, that the indicator is a positive or a negative *number*. We have seen above that the same pair of imaginary roots may have just as much claim to a place in a series of negative numbers, as to a place in a series of positive numbers, and to a place in a series of positive numbers, as to a place in a series of negative numbers; and this is the same as saying that the pair itself is not entitled to a place in either series: it is the *indicator* only of that pair, which can be said, in strictness, to range with positive or with negative numbers, or which can occupy any place among them.

Taking the derived functions in reverse order, commencing with the function of the first degree, if the value (r_1) of x, which causes this function to vanish, causes it to do so between like signs, then is r_1, with its proper sign, the *indicator* of a pair of imaginary roots in the contiguous quadratic function, when this is equated to zero. If a value (r_2) of x, which causes this quadratic function to vanish, causes it to vanish between like signs, then is r_2, with its proper sign, the indicator of a pair of imaginary roots in the contiguous function of the third degree, when *this* is equated to zero, and so on; the sign of r_1, r_2, &c., denoting the region in which the pair of imaginary roots is—not *situated*, but *indicated*. And what, in this case of a pair of *imaginary* roots, is the indicator, becomes, in the case of a pair of unequal *real* roots, a *separator* of those roots.

A pair of roots indicated in any interval $[a, b]$, if they turn out to be imaginary, will be equally indicated in the indefinitely narrow interval $[r-\delta, r+\delta]$, be δ ever so small, r being the indicator. The modification which the coefficients of that quadratic factor of the function to which these imaginary roots are due (in order that the two roots indicated between the above narrow limits may be real roots, the other roots of the function remaining undisturbed) must evidently be such as to make the quadratic factor the complete square, $(x-r)^2$.*

Of course, the same pair of equal roots (r, r) would replace the pair of imaginary roots by making a suitable modification of the final term of the function alluded to, without any interference with the other coefficients; but, then, all the remaining roots of the function would be changed; since, for no one of the values of x, for which the *unaltered* function vanishes, would such evanescence take place when the final term, or the absolute number, *only*, was *changed*.

NOTE.

On the formula [4], in Article (2).

The general expression [4], for the three roots of a cubic equation, is entirely free from superfluous values. The values there symbolised are just *three* in number, the cube root being the only item in the formula which involves multiple values. The symbol r represents *one* only of the two roots of the quadratic equation $Q^2 - 3PP' = 0$; *which* one of the two is entirely matter of choice. If after the root selected has been employed, the other root be introduced into the formula, in its place, we shall get a second expression for x, differing from the first one only in appearance; and, symbolizing the same three values, the analytical investigation of the formula sufficiently shows such to be the case.

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* The quadratic factor, alluded to above, is that which enters the derived equation of *lowest* degree, into which imaginarity is transmitted from the primitive equation; the quadratic factor spoken of belongs to the *primitive* equation only when the imaginarity so enters that it is not transmitted to a *derived* equation.

V.—On the Equation of the Squares of the Differences of a Biquadratic.

By John Casey, LL. D., M. R. I. A., Professor of Mathematics in the Catholic University of Ireland.

[Read April 13th, 1874.]

The following method of finding the equation whose roots are the squares of the differences of the roots of a biquadratic given by its general equation, with binomial coefficients, has been in my possession for some years. It occurred to me, while reading Professor Roberts' solution of the same question, published in Tortolini's "Annali di Matematica." As it is, I believe, shorter and more elementary than the solutions hitherto published, it may be deserving of the attention of mathematicians.

I. *Notation.*

Let $(a, b, c, d, e, \between x, 1)^4 = 0$ be the quartic, then we shall denote $b^2 - ac$, the discriminant of

$$(a, b, c, \between x, 1,)^2 \text{ by } H;$$
$$a^2d + 2b^3 - 3abc \text{ by } G;$$

G is evidently $= \frac{1}{2}\dfrac{d\Delta}{dd}$, when Δ is the discriminant of the cubic $(a, b, c, d, \between x, 1)^3$, and the vanishing of G is the condition that the roots of this cubic may be in arithmetical progression; we shall also denote the quadratic invariant of the quartic, $ae - 4bd + 3c^2$ by I_2, and its cubic invariant or catalecticant

$$ace + 2bcd - ad^2 - eb^2 - c^3 \text{ by } I_3;$$

then, since G, H, I_2 I_3 are functions of the differences of the roots, we have at once, by taking $a = 1$ and $b = 0$, the well-known theorem

$$G^2 = 4H^3 - I_3 - I_2H. \tag{1}$$

II. *Euler's Reducing Cubic.*

Let the quartic $(a, b, c, d, e, \between x, 1)^4 = 0$ be deprived of its second term, and it becomes, making $a = 1$,

$$x^4 - 6Hx^2 + 4Gx + I_2 - 3H^2 = 0, \tag{2}$$

and Euler's reducing cubic is

$$y^3 - 3Hy^2 + 3\left(H^2 - \frac{I_2}{12}\right)y - \frac{G^2}{4} = 0. \tag{3}$$

This becomes by changing y into $y + H$, that is, by taking away the second term, and making use of (1)

$$y^3 - \frac{I_2}{4}y + \frac{I_3}{4} = 0. \tag{4}$$

III. *Equation of Differences.*

If x_1, x_2, x_3, x_4, be the roots of (2), and v_1^2, v_2^2, v_3^2 the roots of (3), we have by Euler's solution,

$$(x_1 - x_2)^2 = 4(v_2^2 + v_3^2) + 8v_2v_3.$$

Hence, if z be a root of the required equation, and a_1, a_2, a_3 the roots of (4)

$$z = 4(a_2 + a_3 + 2H) + 8\sqrt{(a_2 + H)(a_3 + H)}$$

$$\therefore \{z - 4(a_2 + a_3) - 8H\}^2 = 64\{a_2a_3 + (a_2 + a_3)H + H^2\}.$$

Now, by equation (4)

$$a_2 + a_3 = -a_1 \text{ and } a_2a_3 = -\frac{I_3}{4a_1}.$$

Hence, making these substitutions, and putting y for a_1, we get

$$(z + 4y)^2 - 16Hz + \frac{16I_3}{y} = 0. \qquad (5)$$

The question is now reduced to the elimination of y between (4) and (5), which is easily performed, as follows. From (4) we have

$$y^2 - \frac{I_2}{4} + \frac{I_3}{4y} = 0; \qquad (6)$$

and eliminating in succession

$$\frac{I_3}{y} \text{ and } y^2 \text{ from (5) and (6),}$$

we get the two quadratics,

$$48y^2 - 8zy - (z^2 - 16Hz + 16I_2) = 0 \qquad (7)$$

$$8zy^2 + (z^2 - 16Hz + 4I_2)y + 12I_3 = 0. \qquad (8)$$

Again, eliminating y^2 from (7) and (8) we get

$$y = -\frac{z^3 - 16Hz^2 + 16I_2z + 72I_3}{14z^2 - 96Hz + 24I_2}; \qquad (9)$$

and substituting this value of y in (7) we get the required equation—

$$\begin{aligned} z^6 - 48Hz^5 &+ 8(I_2 + 96H^2)z^4 \\ &- 32(32G^2 + 48I_2H + 45I_3)z^3 \\ &- 18(7I_2^2 - 384I_2H^2 + 288I_3H)z^2 \\ &- 384(6I_2^2H + 4I_3H + 5I_2I_3)z \\ &\qquad + 256(I_2^3 - 27I_3^2) = 0. \end{aligned}$$

In the preparation of this Paper, Professor Ball's Memoir on the Solution of the Biquadratic, published in Volume VII. of the "Quarterly Journal of Pure and Applied Mathematics," has been of much use to me.

VI.—On a Spectroscope of the Binocular Form for the Observation of Faint Spectra. By Charles E. Burton, B. A., F. R. A. S.

[Read May 25, 1874.]

The instrument described in this notice was constructed at the instance of Mr. Stoney, out of a grant of money entrusted to me for the purpose by the Royal Irish Academy. Owing to the pressure of other business upon Mr. Grubb and Mr. Spencer, on whom devolved the carrying out of the details of the construction, the instrument has only come into my hands within the last few days, and its capabilities must, therefore, be considered as not yet fully tested.

The binocular form was adopted at Mr. Stoney's suggestion, in order to secure that great increase of power and comfort in observation of faint and difficult objects which results from the co-operation of both eyes. I append an outline sketch of the spectroscope, of which the following is a description.

The same parts are designated by the same letters in both plan (Fig. 1.) and elevation (Fig. 2.), and are drawn to the same scale, namely, one-sixth of full size. The working parts are sustained and connected by a mahogany frame-work *B*, which protects the internal arrangement, and gives support to the recording table, marked *Slider*.

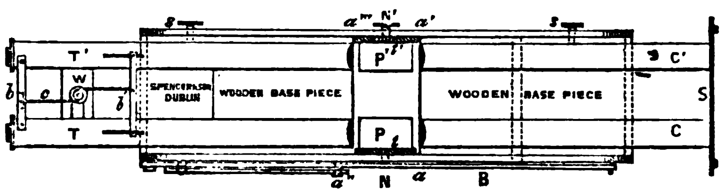


Fig. 1.

Collimators. The collimators C C', which carry the slit S are fixed upon a mahogany base-board, movable in a vertical plane about the axis a a', and capable of being fixed at any required inclination to the line h h by means of a binding screw s, which passes through a circular slot in B into the wooden base-piece.

The Prisms. P and P' are the prisms, worked as nearly as possible to the same form. The three faces of each prism are polished, so that any one of the three angles may be employed to form a spectrum. In each prism the three angles are not equal, but subtend respectively 58°, 60°, and 62°. The range of dispersion obtainable with a single prism is, therefore, very considerable, if the three angles are made use of in succession.

This property of each prism is made available by mounting it on a circular wooden disc, centrally perforated to admit a binding screw,

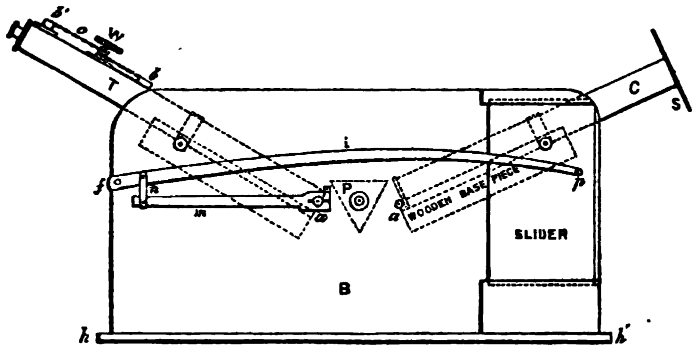


Fig. 2.

which secures it to the inner side of *B*, and when tightened prevents the disc from rotating. The discs and binding screws attached to the prisms are shown at *t t′*, *N N′*.

The observer can readily turn round the wooden disc with the attached prism, after slackening *N*, and he can fix the prism again in any position he pleases by once more tightening *N*. The two prisms are perfectly independent of one another.

Telescopes. The telescopes *T T′* are fixed, like the collimators, to a single mahogany base-board, and move also in a vertical plane about the axis of the spindle *a‴ a*,″ which moves with the base-board. One extremity of this axis, that marked *a″*, is enlarged for the reception of the clamp of the recording apparatus, to be mentioned presently. The adapters, carrying the eye-pieces, are connected together by a pair of cross bars *b*, *b′*, which are secured to them by screws passing through the slots in the outer tubes shown in the plan,

Focussing of eye-pieces. The focussing movement is communicated to the eye-pieces simultaneously as follows. A piece of flat linked chain, *c*, is fastened at one extremity to the cross bar nearest the object glasses, passed twice round the spindle *W*, which is fixed to the wooden base plate, and secured by a clip arrangement to the cross bar above the eye-pieces. On turning *W*, the chain is wound one way or the other, and the adapters move with it.

Each of the eye-pieces has an independent sliding motion in its own adapter. In the focus of each eye-lens is a pointer, of a wedge form, borne by a split tube, fitting moderately tight into the eye-piece adapter. These pointers are capable of adjustment in every direction.

Recording apparatus. The recording apparatus is a modification of that devised some years since by Mr. Grubb, and found by those who have employed it to combine a very considerable amount of accuracy with great facility in use, dispensing also with the necessity for a reading lamp at the time of observation, and thereby preventing that loss of time which is inevitable if micrometric apparatus of the ordinary construction be employed for the measurement of extremely faint spectra.

The bar *m* (Fig. 1.) is thickened and split at one extremity to receive the end a'' of the axis on which the base-board carrying the telescopes moves.

The two prongs of the fork thus formed can be brought together so as to grip a'' tightly, by means of a small capstan-headed screw.

The link *n* connects the free end of *m* with the recording arm *i*. The two ends of *n* are perforated with square holes, the diagonals of the squares being longitudinal and transverse to the link.

Through these square holes pass screws into *m* and *i*, in which they are fixed. Owing to the position of the holes, these pins work practically in V bearings, and steadiness of movement is thereby secured.

i moves on a fulcrum at *f*, and carries near its free extremity a pin *p*, directed inwards towards the slider. By pressing the finger gently on the outer side of the arm *i* near the end, a dot may be made on a card, and a record thereby made of the position of the arm at the time. The slider moves in either direction readily, parallel to the line *hh*. If *m* be changed to a'', and the telescopes be raised, *m* will be constrained to rise also, and by means of the link *n* will raise *i* and *p* with it.

Since the distance from the object glass of the telescope to the final image is 9 in., *m* being 4 in. long, *nf* $1\frac{1}{2}$ in., and *fp* 15 in., any motion of the pointer, if small, will be multiplied at *p* by the improper fraction

$$\frac{4 \times 15}{9 \times 1\cdot5} = 4\cdot4\,;$$

an amplification which is found to be practically sufficient.

The slit is formed of two long long brass rules, jointed together in exactly the same manner as for a parallel ruler.

The links are perforated at their centres for two screws, one for each, on which they severally turn. To each extremity of the lower rule is fastened one end of a piece of flat linked chain, the central portion of the chain being coiled twice about a spindle, on which is fixed a lever about 6 inches in length.

By altering the position of this lever, the chain is drawn one way or the other, and causes the rules to move.

As the axes on which the links turn are situated in the centre of their length, the approach of the jaws of the slit to a line between them will be the same for each of them, and the desired fixity of the centre of the slit opening, and therefore of the spectral lines, with respect to the pointer, is thereby secured.

It is hoped that this instrument may be useful in the study of the spectra of the Aurora and Zodiacal Light, which are not yet thoroughly known; the first on account of its caprscious variableness, the latter by reason of its extreme faintness. The last-mentioned difficulty, it is hoped, may be overcome, by the use of this special instrument, which brings both the eyes into use, and by the improvement of an opportunity which now offers for the study of the Zodiacal Light under favourable circumstances, as regards climate, in the Mauritius.

In conclusion, I have to thank Messrs. Stoney, Grubb, and Spencer for numerous suggestions and improvements in the design of the instrument, and to apologise for the unavoidable haste with which this notice has been drawn up, previously to my departure to Rodriguez as one of the expedition to observe there the transit of Venus.

VII.—On Fossils from the Upper Old Red Sandstone of Kiltorcan Hill, in the County of Kilkenny. Report No. 1. By Wm. Hellier Baily, F. G. S., &c.

[Read February 9, 1874.]

Great interest in the fossil plants of Kiltorcan has been shown by eminent scientific men, especially those of foreign countries, who have made fossil botany their study; and among those latter, with whom I have corresponded on the subject, I may mention Professor Geinitz, of Dresden; Dr. Schimper, of Strasbourg; Professor Heer, of Zurich; Principal Dawson, of Canada; Professor De Koninck, of Liége; and M. Crepan, of Brussels—all of whom testify in their communications to the scientific importance of investigating the subject.

Additional interest arises not only from the perfect state of preservation in which these fossils occur, but from the fact that they, with their associated fossil fauna, assist in a material way to determine the fresh water, or marine origin, of the great mass of old red sandstone strata developed in the British Islands, as well as on the continent of Europe.

Although this report relates more especially to the fossil plants, it will not perhaps be thought irrelevant to allude to the associated animal remains of mollusca, crustacea, and fish discovered at the same place.

The quarry from which the specimens now exhibited were collected, in consequence of its remote situation, has not been much excavated, except for scientific purposes; it is situated between Kilkenny and Waterford, near the Ballyhale railway station, on an elevated ridge of Old Red Sandstone ("yellow sandstone" of Sir Richard Griffith), which rises gradually from beneath the limestone plain to heights of 400 or 500 feet, and in some places, as near Jerpoint, to as much as 800 feet above the sea level.

The beds of fine grained greenish sandstone dip at a very slight angle, and separate easily into slabs of large size, some of them being covered by plant remains; the surfaces of these slabs are sometimes stained quite black, probably with manganese or iron, and are very disappointing when found in this state. The most frequent plant is *Palæopteris Hibernicus;* first noticed by the late Professor Edward Forbes at the Belfast meeting of the British Association in 1853, under the provisional name of Cyclopteris, afterwards referred to Adiantites by M. Adolphe Brongniart, and now placed by Professor Schimper in his genus Palæopteris—that eminent authority, in his valuable work, "Traité de Paléontologie Végétale," stating that it differs from Cyclopteris in the arrangement of its leaflets, and from Adiantites in its mode of fructification.

Magnificent fronds of this, the most ancient fern, are impressed upon the slabs with remarkable distinctness, so much so that even the venation on the leaflets is clearly discernible. Some of these fronds are between four and five feet long and three feet broad. The peculiar mode of fructification by a transformation of sterile into fertile pinnules is well shown in some specimens, and so also is the basal portion of the frond. Two additional species of fossil ferns have been described by me from this place under the names of *Sphenopteris Hookeri* and *S. Humphresianum*, both of which are comparatively rare.

Another plant, frequent at Kiltorcan, having a fluted or ribbed stem, its upper portion branching, I formerly considered to be identical with *Sagenaria Velthiemiana*. Professor Schimper, however, who had frequent opportunities of comparing its fruit with that of *S. Velthiemiana*, assures me that it differs greatly from that species; believing it to be an undescribed plant, he has named it *Sagenaria Bailyana*. The central axis of this plant is seen in some specimens, indicating its loose texture and its alliance to Sigillaria.

A fine example of this plant was discovered by me and Mr. Alex. M'Henry, who assisted me in these explorations. After excavating to a depth of about four feet, we uncovered a portion of the stem and traced it out as far as possible; it rested on the surface of a bed which was much jointed, consequently it was not possible to preserve it entire. Careful sketches and exact measurements were however made by me on the spot. Unfortunately we could not get at the termination to see if the stigmaria-like roots were attached; this must remain a problem until further excavations can be made.

The total length of this specimen was 20 feet 4 inches, the stem at its lowest portion being six inches in diameter. It commenced to branch at 15 feet from the visible termination; after the first division the branches are one and a half inches broad, continuing to diminish until they became reduced to a quarter of an inch in breadth.

The upper portion of its branches corresponds with *Cyclostigma* or *Lepidodendron minuta* of Dr. Haughton.

A central axis traverses the whole of the plant, composed of soft tissue, with an open cellular structure, as in Sigillaria and Stigmaria.

What I believe to be the roots and rootlets of this species permeate certain beds beneath, just as Stigmaria does the clay immediately under the coal.

Cone-like bodies are frequent in the same bed; they somewhat resemble Lepidostrobus of the coal strata, and are composed of elongated scales, terminating in long linear processes; these scales show large and very distinct sporules. They are evidently the fruit of a Lycopod, but have never yet been found attached to the Sagenaria, to which it is presumed they belonged.

A third description of plant, extremely abundant at this place, has been described by Dr. Haughton under the name of Cyclostigma. They usually occur in a fragmentary state, and are much compressed. One of the most important additions to our knowledge of these plants is a specimen in the collection now obtained; this I believe to be a young example of *Cyclostigma Kiltorkense*. It was found in a layer with *Palæopteris Hibernicus*, about two and a half feet below the commencement of the rock; it shows what has never been met with before, the rounded base, with attached rootlets. The total length of this specimen is two feet three inches, its greatest diameter being one inch and one-eighth. The widely distant stigmæ, absence of longitudinal rib-like markings, and different character of root, distinguish it essentially from the Sagenaria, or from *Knorria Bailyana*, with which some Palæophytologists have sought to identify it. This plant appears to have been less cylindrical than the Sagenaria. I am inclined to believe that the fine specimen in the collection of the Royal Dublin Society, named by M. Adolphe Brongniart *Lepidodendron Griffithsii*, is the terminal portion of this species. In the collection made by the Geological Survey, also from this place, there is a similar portion, showing the blunt brush-like apex, the stigmæ becoming more closely arranged towards the top, and the rigid linear leaves, three or four inches long, spreading out on each side at regularly decreasing intervals from a half to the eighth of an inch.

The associated animal remains are, of mollusca, one example only, the large bivalve shell named by Professor Forbes *Anodonta Jukesii*. Its close resemblance to the recent *Anodonta cygnæus*, the large freshwater muscle, common in some of our lakes and rivers, sufficiently justifies its generic alliance, and assists materially in proving the freshwater origin of the deposit.

Several species of crustacea have from time to time been added to the list of fossils found at this place. The late Mr. Salter first indicated the probable existence of Eurypterus from a very fragmentary specimen; this indication I have been enabled to confirm by the discovery of better specimens, and have named a species *Pterygotus Hibernicus*. This Mr. Woodward has since referred to Eurypterus.

In addition to this, we collected a Limuloid form, which I have called *Belinurus Kiltorkensis*, and a Phyllopod, *Proracaris MacHenrici.*

The fish remains are also of considerable interest, and are eminently characteristic of Old Red Sandstone strata. They consist for the most part of detached portions, comprising a few conical teeth, resembling those of Dendrodus or Bothriolepis, jaws with teeth most probably belonging to Coccosteus, and osseous plates of the same fish, these being the most numerous. A small species of Pterichthys also occurs, and numerous scales of Glyptolepis. Only in one instance were we successful in obtaining anything like an entire fish; it belongs to the last-named genus, and I believe it to be identical with *Glyptolepis elegans.*

The great importance of the fossils of this locality cannot, I feel convinced, be overrated, and it will doubtless yield still more valuable results. Duplicate sets of these fossils have already been supplied to various scientific institutions both in our own country, on the Continent, and in America. The letters received in acknowledgment sufficiently testify as to the appreciation in which they are held.

Professor Oswald Heer, in a paper read before the Geological Society of London on the Carboniferous flora of Bear Island (lat. 74° 30′), enumerates 18 species of plants, indicating, according to the author, a close approximation of the flora to that of Tallow Bridge and Kiltorcan; also to the Greywacke of the Vosges and the southern Black Forest, and the Verneuiler shales of Aix, and St. John's, New Brunswick. He refers this flora to the Lower Carboniferous, and therefore argues that the line of separation between the Carboniferous and Devonian must be drawn below the yellow sandstone. The prevalence of fishes of Old Red Sandstone type in the overlying slates he regards as an argument to invalidate the conclusion.

Sir Charles Lyell, in the discussion which followed, remarked that the yellow sandstone of Dura Den in Fife, and of the counties of Cork and Kilkenny in Ireland, contain fish exclusively Devonian, and others, such as the genus Coccosteus, which are abundantly represented in the Middle Old Red Sandstone, and by one species only in the Carboniferous formation. The evidence derived from these fish inclined him, therefore, to the belief that the yellow sandstone, whether in Ireland or Fife, should be referred to the Upper Devonian and not to the Lower Carboniferous.

VIII.—Notes on the Myology of the Coati-mondi (Nasua Narica and N. Fusca) and Common Martin (Martes Foina). By H. W. Mackintosh, B.A.

[Read April 13, 1874.]

The following remarks are founded on the dissection of one specimen of *Nasua narica*, one of *N. fusca*, and two of *Martes foina*. They all formed part of the collection in the Dublin Zoological Gardens, and having died during the summer of 1873, were forwarded for examination to Professor Macalister, who kindly gave me the opportunity of assisting him in dissecting them.

We noticed the following points of general anatomy:—

There was no recessus pharyngeus, a rudimental bursa pharyngei, small Eustachian tubes, and black lymphatic glands in *N. narica;* in *N. fusca* the platysma is very strong, running upwards and inwards to the middle line; *Martes foina* resembles *N. narica* in having black lymph glands.

The facial muscles in *N. narica* are;—

Orbicularis palpebrarum simple, arising from the definite ocular tendon; levator labii superioris large, arising from the maxilla in front of the orbit and running downwards and forwards to be inserted tendinously into the upper lip; levator alæ nasi, a very large muscle arising just above the infra-orbital foramen, and running forwards underneath the last-named muscle to be inserted by an expanding tendon into the dermis of the end of the elongated snout, which it elevates and lateralises; its tendon is slightly united to levator labii superioris, and the large infra-orbital nerve runs parallel to and underneath it; levator anguli oris consists of vertical fibres attached underneath the eye; depressor alæ nasi, from the alveolus vertically upwards to the sides of the alar cartilage; retrahens aurem, very large, with a detached slip from the fascia of the middle line of the neck; transversus auriculæ is also large, and atrahens aurem is a strong round bundle of fibres from the zygoma. The tongue has the usual muscles.

In *N. fusca* levator alæ nasi and levator labii superioris form a single muscle; retractor nasi is enormously developed; there is a double retrahens aurem, a single zygomaticus; mandibulo-auricularis is strong; there is a transversus depressor auris, and a normal masseter.

The muscles of the head and trunk in *N. narica* are;—

Rectus capitis anticus major arising from the five upper cervical vertebræ, and inserted directly into the bulla tympani; rectus capitis anticus minor is very small, arising from the atlas, and inserted as usual; digastric, arising from the post-tympanic and paroccipital processes, covers the bulla tympani, has an inscription (which is long in *N. fusca*), and is inserted into the posterior third of the mandibular ramus. The parts of longus colli are not separable. Scalenus anticus is small and normal; scalenus posticus extends from the four lower cervical transverse processes to the eight upper ribs. The sternohyoid, sternothyroid, thyrohyoid, and cricothyroid are as usual. In *N. fusca*, sternocostalis arises from the two upper sternebers and is inserted into the first rib; the brachial artery overlies and the brachial nerve underlies the supracondyloid foramen; the muscles of the back of the neck are of the ordinary carnivore type; scalenus posticus runs from the third cervical vertebra to the second, third, fourth, fifth, and sixth ribs; scalenus medius extends from the sixth cervical vertebra to the first rib. None of these muscles were examined in the Martin.

In the fore limbs:—

Trapezius consists in all of three parts, clavicularis (·08*), scapularis superior (·07), and scapularis inferior (·05); the first of these arises from the occiput in the coatis, and from the spine of the axis as well in the martins, and is inserted into the rudimentary clavicle in *N. narica* and Martes; in *N. fusca* it joins cleidomastoid at its insertion into the clavicle, is united to brachialis anticus, and sends a slip to the humerus; the superior portion of scapular trapezius arises from the spines of all the cervicals except the atlas and from those of the ten upper dorsals; it has the usual insertion into the scapular spine, quite separate from the inferior division; in *N. narica* it is united at its origin to the clavicular trapezius, but separated at its insertion by trachelo-acromial. Trapezius scapularis inferior varies somewhat in position in all. In *N. narica* it arises from the third, fourth, fifth, and sixth dorsals, and is inserted into the posterior edge of the scapula; in *N. fusca* the origin is from the six upper dorsals, and the insertion is into the root of the scapular spine; finally, in Martes it arises from the second, third, fourth, fifth, sixth, and seventh dorsals, and is inserted into the lower border of the posterior half of the scapular spine.

Sternomastoid (·08) arises from the presternum in all, is inserted into the paroccipital process in *N. fusca*, and into the paramastoid in the other three; the two sternomastoids are mesially connivent in the martins. Cleidomastoid (·04) extends from the paroccipital to the clavicle in *N. fusca*, and from the paramastoid to the same place in *N. narica* and the martins. Omohyoid was absent in the coatis and exceedingly slender in Martes. Trachelo-acromial (·05) presents nothing of importance.

Rhomboid (·07) is indivisible in Nasua and arises from the occiput, all the cervicals, and the five upper dorsals; the insertion is as usual. In Martes the occipital is distinct from the major portion at its origin, which is very far out on the occiput; the latter part arises from the six lower cervicals and from the two upper dorsals, and is inserted into the scapular spine along with the occipital segment. Teres major (·08) is united at its insertion with the latissimus dorsi in the coatis, but separate from it in Martes. Teres minor (·01) is small but distinct in all, with a long tendon of origin and insertion in *N. narica*; it is inserted behind and above scapular deltoid in *N. fusca*.

Latissimus dorsi (·23) arises from the dorsal spines (from the sixth to the tenth in *N. narica*, from the eighth downwards in *N. fusca*, and from the third downwards in Martes), from the three lower ribs and from the lumbar fascia, and has the usual humeral insertion. Pectoralis minor was absent in all. Pectoralis major (·30) has a presternohumeral slip in all; the rest of the muscle (bilaminar in *N. narica*, unilaminar in Martes) arises from the whole length of the sternum, and is inserted into

* The Numbers refer to the weights in *N. narica* in decimals of an ounce avoir.

the humerus as usual. In *N. fusca* it consists of three parts—one extending from the entire sternum to the pectoral ridge of the humerus, a second going from the six anterior mesosternal sternebræ to the greater tuberosity of the humerus and tendon of supraspinatus, and the third arising from the abdominal parietes, inserted below the last, and united with pectoral quartus. Pectoralis quartus (·14) arises from the cartilages of the lower ribs and from the fascia over them, and is inserted in the axilla in close contiguity with latissimus dorsi (and pectoralis major in Martes).

Subclavius was absent in all, unless represented by the presternohumeral slip of pectoralis major, which is very constant in carnivora. Coracobrachialis was very small, and represented only by the short variety in the coatis; but in the martins both longus and brevis existed, arising by a common tendon from the coracoid process; the former was inserted by a tendinous sling extending from the latissimus dorsi tendon to the lower third of the humerus, and the latter into the same bone, above latissimus and separate from it.

Deltoid consists of three parts, clavicular (·07), scapular (·04), and acromial (·03), as usual. The first of these is only remarkable for its very low humeral insertion in *N. narica;* the second arises in *N. fusca* from the fascia along the inferior border of the infraspinous fossa, and in Martes from the outer half of the scapular spine; the third has some of its fibres continuous with those of brachialis anticus, and shows a distinct inscription at the point of junction of the two, in *N. narica*. Supraspinatus (·10) and infraspinatus (·9) are normal in all, the former being the larger. Subscapularis is also normal, and has respectively three, four, and five tendinous planes in *N. narica*, Martes, and *N. fusca*. There was no separate pre-scapular slip in the first two, but in *N. fusca* it was quite distinct, passing down over the tendon of the rest of the muscle.

Serratus magnus (·16) arises from eight ribs and six cervical transverse processes in *N. narica*, from nine ribs in *N. fusca*, and from seven ribs and five cervical transverse processes in Martes, and is inserted as usual. The cervical origin was not recorded in *N. fusca*. Serratus posticus superior arises from the fascia of the back, and is inserted into the third, fourth, fifth, sixth, seventh, eighth, and ninth ribs in *N. narica*, and into the fifth to the fifteenth in *N. fusca*. Serratus posticus inferior is inserted into the three lower ribs in *N. narica*.

Biceps (·06) is glenoradial in its attachments as usual. Brachialis anticus (·06) arises from the whole of the external aspect of the humerus, and is inserted into the ulna. Triceps longus (·10) not very separate from externus in the coatis, though perfectly so in Martes, has two heads in *N. narica*—one from the edge of the glenoid cavity, and the other from the axillary border of the scapula; the insertion is olecranal as usual; it is fused with triceps externus in the *N. fusca*. Triceps internus and externus (·10) are fused in *N. narica*, but moderately separate from one another in the other animals; externus is the larger of the two in Martes. Dorsi-epitrochlearis (·05) arises in *N. narica* from latissimus dorsi and by an inscription from teres major, and from the former of these two muscles alone, in *N. fusca* and Martes, it is inserted as usual into the olecranon. The anconei are united to biceps in *N. narica*; anconeus internus arises from the supracondyloid process in *N. fusca*.

Pronator radii teres (·03) arises from the usual place in all, but presents a slightly different insertion in each; in *N. narica* it is inserted into the lower three-fourths of the radius, in *N. fusca* into the middle third, and in Martes into the distal half of the same bone; it was thick and slightly bilaminar in *N. narica*.

Flexor carpi radialis (·015) is normal in all. Palmaris longus (·015) has two heads—one fleshy and the other tendinous in *N. narica*; the insertion is into the palmar fascia in all, and in the marten it is connected with the superficial abductor minimi digiti; in *N. narica* there is an accessory palmaris, arising from the upper third of the forearm, overlying the ulnar flexor of the wrist, and inserted into the fascia of the palm by a slender tendon. Flexor carpi ulnaris (·03) is bicipital, and is inserted into the pisiform as usual. The two heads are united at the middle third in *N. fusca*. Flexor digitorum sublimis arises from the flexor digitorum profundis (just above the annular ligament in Martes), and is inserted by four tendons into the fascia of the four digits, the pollex not being supplied by it. Flexor digitorum profundus and flexor pollicis longus (condyloid part ·06, radial ·08) are united, have the usual five heads (three median, one olecranal, and one radial), and send a tendon to the pollex and to each of the digits; in Martes the pollex receives its tendon from the central olecranal head. There are four lumbricales in all, one on the pollical side of each digit tendon. Pronator quadratus occupies the lower fourth of the fore arm in all.

Supinator radii longus (·04) is a large muscle in all, arising from the external ridge of the humerus and inserted into the distal end of the radius. Extensor carpi radialis longior (·02) and ex. carp. rad. brevior are quite separate in *N. fusca*, and partly so in *N. narica* and Martes, and have the usual insertions. Supinator radii brevis occupies the upper two-thirds of the radius in Nasua, and the upper half in Martes, and has no sesamoid bone in its origin. Extensor digitorum longus (·02) arises as usual from the outer condyle of the humerus, and is inserted into the dorsal aspect of each of the four digits. Extensor minimi digiti (·01) is in reality an extensor of the third, fourth, and fifth digits in *N. fusca* and Martes, sending a tendon to the dorsal aponeurosis of each of those fingers; but in *N. narica* there is a separate extensor tertii et quarti digiti (·015), lying in the same groove as extensor minimi, but distinct from it. Extensor carpi radialis (·02) has a very small olecranal origin, and no ulnar one in *N. narica*, but is large and flat in Martes with the usual origin and insertion. Extensor ossis metacarpi pollicis (about ·02) arises in all from the whole length of the ulnar and interrosseous membrane, and is inserted into the radial sesamoid of the carpus; it is a large muscle in *N. fusca*.

Extensor secundi internodii pollicis et indicis is single-headed in the coatis and bicipital in the martins, the tendons in the latter uniting and then diverging to be inserted (as in *N. nasua*) into the pollex and index. In *N. fusca* the index tendon sends a very fine tendinous slip to the middle finger; there is also in this animal a thin palmaris brevis extending over the flexor tendon of the thumb.

The muscles of the fore foot in *N. fusca* are—a short abductor pollicis; an adductor from the front of the carpus; a double abductor indicis, one head arising from the carpus, and one from the metacarpus, both uniting to form a single tendon; a bicipital adductor indicis; a single-headed abductor and adductor medii; an adductor minimi digiti arising from the pear-shaped pisiform, and by a slip from the unciform; a flexor brevis; an abductor minimi digiti, as usual; an abductor and abductor annularis, also normal. The interossei are normal in *N. narica.* In Martes there are an abductor pollicis, extending from the radial sesamoid and annular ligament to the pollex; an abductor pollicis and flexor brevis pollicis, both normal; an abductor minimi digiti, arising from the pisiform; and an adductor minimi digiti, from the front of the carpus; a flexor brevis minimi digiti, from the unciform; and an opponens minimi digiti, which is a dismemberment of the abductor; there are besides two interossei for each digit.

In the hind limb:—Sartorius (·08) in the coatis has a wide origin from the anterior superior spine of the ilium as usual, and a double insertion—one the ordinary tibial insertion, and the other into the patella and border of the condyle of the femur; in *N. fusca* the tibial portion has its upper part attached to gracilis. In Martes it arises from the angle of the crest of the ilium and from the inferior edge of that bone, and is inserted into the patella and fascia of the upper extremity of the tibia along with gracilis.

Psoas parvus (·03) is small in *N. narica,* and sends a slip to the lumbo-sacral articulation; in *N. fusca* it is wide and strong, with the usual attachments, and in Martes it arises from the bodies of the third, fourth, fifth, and sixth lumbar vertebræ, and is inserted as usual into the pectineal line. Iliopsoas (·12) is normal in *N. narica*; in *N. fusca* it is a psoas major, with a small iliac origin; in Martes it arises from the three lower lumbar vertebræ, is inserted fleshy into the pectineal line, and by a tendon into the lesser trochanter.

Pectineus (·04) has the usual origin, and is inserted into the upper half of the femur in the coatis, and into the upper fourth in the martins. Adductor primus (·09) is normal and quite distinct in Nasua; in Martes there is a second slip arising from the posterior half of the horizontal ramus of the pubis, and inserted into the back of the femur just above the condyles. Adductor secundus (+ adductor tertius ·22) is distinctly bilaminar in *N. narica,* but not in the others; it is attached as usual. Adductor tertius is separable with difficulty from adductor secundus, arising in *N. fusca* from the spine of the pubis, and having a narrow insertion into the middle point of the femur. In Martes it is a small slip arising just in front of the pectineus, and behind the pectineal tubercle; its insertion overlies that of pectineus. Quadratus femoris (·04) arises as usual from the tuber ischii anterior to the origin of biceps, and is inserted into the intertrochanteric line. Obturator externus (·07) and internus (·05) are both present and separate in all; the superior gemellus is large in *N. narica*, but the inferior is absent; both are present and distinct in *N. fusca*, and they are fused with obturator in Martes.

Agitator caudæ (·06) in *N. narica* arises from the first caudal vertebra, and is inserted into the lower two-thirds of the outside of the femur; it is represented by the caudal origin of the biceps in Martes.

Pyriformis (·05) arises from the third and fourth sacral vertebræ, and is inserted as usual just behind the tendon of the gluteus medius.

Gluteus maximus (·07) arises from the gluteal fascia and first caudal vertebra (and from the side of the sacrum as well in Martes), and is inserted into the great trochanter, and more especially into its prominent lower part in the coatis. Gluteus medius (·15) is large and normal. Gluteus minimus (+ gluteus quartus ·03) is fused with gluteus quartus in *N. narica*, though separate from it in *N. fusca*; the latter is absent in the martins. Tensor vaginæ femoris (·05) is small and normal in *N. narica*, arises from the anterior superior spine of the ilium in *N. fusca*, and from the inferior edge of that bone in Martes, and is inserted into the fascia of the thigh as usual; it is scarcely separable from gluteus maximus.

Biceps femoris (·17) arises in Nasua from the tuber ischii, and in Martes from the first and second caudal vertebræ as well, and is inserted in *N. narica* into the upper two-thirds of the leg; in *N. fusca* into the upper half, and in the martin into the fascia of the thigh and upper half of the tibia. Biceps accessorius (·02) arises along with agitator caudæ, and is inserted along with biceps in *N. narica*; it arises along with the caudal head of semitendinosus, and is inserted into the middle of the fibula in *N. fusca*; it was not distinct from biceps in the martin.

Semimembranosus (·11) in the coatis is united to adductor primus except at its insertion, which is tibial as usual; in Martes it is quite separate, extending from the tuber ischii to the top of the tibia. Semitendinosus (·11) arises in Nasua by two heads—one from the tuber ischii as usual, and the other tendinous from the first caudal vertebra; they unite at the inscription, which is about half way down the muscle, and are inserted as usual into the tibia close to sartorius. There is only the single ischial head in Martes, and the insertion is into the tibia at the point of junction of the upper and middle thirds. Gracilis has a wide origin from nearly the whole of the horizontal ramus of the pubis, and is inserted into the tibia, inseparably from sartorius in *N. narica*, but distinct from, although closely applied to, it in *N. fusca*.

Rectus femoris (·10) has one head, and is moderately separate from vastus externus (·14), which is normal and distinct from vastus internus (+ cruræus ·06), the latter being inseparable from cruræus. Quadriceps extensor cruris presents no feature of importance in Martes, all its parts being more or less fused. Popliteus (·03) is normal and devoid of a fabella in *N. narica*, with an insertion into nearly the upper half of the tibia in *N. fusca*; in Martes there is a sesamoid in the tendon of origin, the insertion is into the upper half of the tibia in one specimen, and into the upper third in the other (smaller) one. Gastrocnemius externus (·06) has a fabella, and is inseparable from the next muscle at its origin in the coatis; there is a fabella in the origin in the larger of the two martins. Gastrocnemius internus (·07) has no sesamoid in *N. narica* and Martes, but there is a small one in *N. fusca*. Plantaris (·05) has the usual origin and insertion (plantar fascia); there is a sesamoid in its origin in the coatis, but not in the martins, in which animals this muscle is surrounded by gastrocnemius externus.

Solæus (·05) is fibular in origin and calcaneal in insertion as usual; it is entirely fleshy in Nasua and in one of the martins, in the other, however, there is a tendinous origin becoming fleshy about half way down the leg.

Flexor digitorum longus (·04) and flexor hallucis longus (·08) are both normal, the latter being as usual the larger. They unite to form a single tendon, which again subdivides to send one tendon to each of the five digits. Tibialis posticus (·04) arises as usual in Nasua, and is inserted into the astragalus, scaphoid, and internal cuneiform bones; in Martes the origin is very high up on the tibia, and the insertion is into the scaphoid only. Flexor digitorum brevis (·01) arises from the tendon of plantaris, and is in fact the fleshy part of that muscle on the sole or the foot; it sends a tendon to each of the four digits. Flexori longo accessorius (·02) arises from the calcaneum, and is inserted into the side of the tendon formed by the union of flexor hallucis and flexor digitorum.

Tibialis anticus (·17) is single and normal in Nasua, but in Martes there are two separate muscles—one arising a little behind the other from the top of the tibia; the two tendons are inserted side by side. Extensor hallucis (·02) arises from the upper half of the tibia, and has the usual hallucal insertion in Nasua, but is absent altogether in the martins. Extensor digitorum longus (·03) arises as usual from the external condyle of the femur, and sends a tendon to each of the four digits. Peroneus quinti (·01) brevis (·03), and longus (·04), present no deviation from the ordinary carnivore type. Abductor ossis metarsi minimi digiti is large in all, arising from the under surface of the calcaneum, and inserted into the base of the fifth metatarsal. Extensor brevis minimi digiti (·01) is normal in the coatis. In *N. fusca* there is an abductor and an adductor for each digit, adductor indicis being bicipital. In *N. narica* the muscles of the hind foot are—Adductor hallucis, extending from the head of the middle metatarsal to the outer sesamoid bone; abductor and flexor brevis hallucis, normal; and interosseous abductor and adductor, each for index; medius and annularis, and the latter of the two, for minimus, which has a special abductor; there is also a special abductor for the hallux.

IX.—On some Points in Bird Myology. By A. Macalister, M.B., Professor of Comparative Anatomy, Dublin University.

[Read April 27, 1874.]

The difficulties in the classification of birds have led many recent zoologists to seek for special principles of classification whereby to subdivide that exceedingly compact and natural class; but, except the skull-classification of Professor Huxley, there has not been anything proposed more satisfactory than the old Cuvierian arrangement.

The active and observant prosector of the Zoological Society of London, Mr. A. H. Garrod, has proposed two new points as bases of classification—one, the arrangement of the nasal bones and their surrounding parts; the second, the varieties in the muscular system.

The author of the "Ornithologiskt System" has used some of these muscular characters as of taxonomic value; but Mr. Garrod, from an extensive range of dissections, has tried to use the presence or absence of some muscles as elements in classification.

The muscles used thus by Mr. Garrod are: 1st, the caudo-femoralis—a muscle which passes from the tail to the linea aspera; 2nd, the quadratus femoris, which extends from the ischium to the femur, above the last (this muscle Mr. Garrod calls accessory femoro-caudal; but it is most probably the homologue of the quadratus femoris, as its nerve arises high up from the roots of the nervus tibialis); 3rd. the semitendinosus; 4th, the femoral head of the semitendinosus; 5th, the long muscle (called rectus by Meckel, gracilis by Cuvier, Owen, and Huxley, but named ambiens by Mr. Garrod).

Mr. Garrod divides birds into two great groups—those with and those without a rectus femoris. Those with he calls Homalogonati; those without he calls Anomalogonati. Among the Homalogonati, however, he includes the Stork, Pelican, Jabiru, and Ardeidæ, as well as the Owl, Grebes, and Auks, none of which possess such a muscle.

Among the Anomalogonati there is not much of myological variation. Macrochires have no quadratus nor semitendinosus, and this Mr. Garrod has noted. Coccygomorphæ and Passerinæ resemble each other in having no quadratus but a semitendinosus; but while Cuculus has a rectus, and belongs to the next group, the others of the order do not. If the rectus be of true taxonomic value, the Ardeidæ, Podicipidæ, Alcidæ, and Phœnicopteridæ should be introduced here.

The Homalogonati are more variable. The femoro-caudal is absent in the Ostrich, Grebe, Otis, and Flamingo; in the last-named we failed to find a rectus femoris, though Mr. Garrod has found one; so this muscle appears to be subject to variety. The Pelican, likewise, we found to have no femoro-caudal, though Sula has one, and also Phalacrocorax. The quadratus femoris is absent in Parrots, Pelicans, and Storks, according to Mr. Garrod; but here there are also elements of variety; for in *Pelicanus onocrotalus* and *Ciconia alba* I have found it present, and while in Seagulls it is absent, in the Albatross it is present, and it also exists in Sula.

These are but specimens of the result of the application of myological varieties for primary taxonomic purposes.

Muscular characteristics have undoubtedly a very great secondary importance in classification, and as subordinate order and family characters, none are more important; but they seem to fail utterly when we take them primarily or alone, and try to frame a system by them.

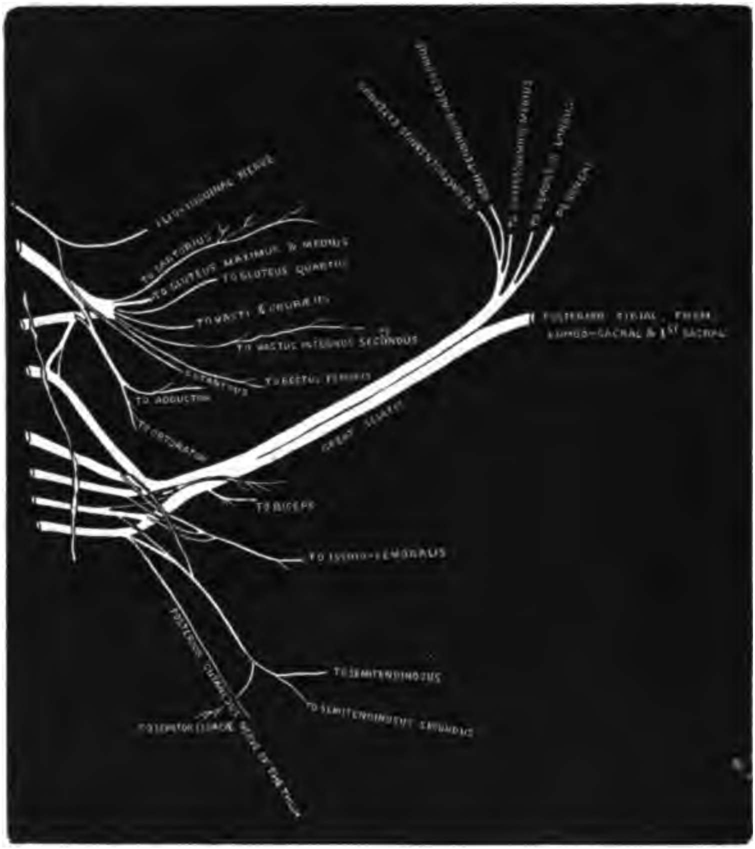
There are other muscles which may be utilized for these secondary classificatory purposes, as variable among birds. The iliacus, which is absent in the Phasianidæ (probably in all the Rasores), but present in Pelargomorphæ, Cecomorphæ, Aetomorphæ, Geranomorphæ, &c. A separate gluteus minimus, distinct from gluteus quartus, is a rarely present muscle (Lophophorus). The second vasti are also important bird muscles, and the popliteus, which may be femoro-tibial or fibulo-tibial. The soleus is also variable in its existence, present in Sula Mycteria, Ciconia. The plantaris is a constant muscle, and only varies in the distribution of its extended tendons, which may go to the second, third, or second, third, and fourth toes. The flexor digitorum sublimis is very constant in all birds, with its two perforating tendons. The tibialis anticus is also constant, with its two parts, femoral and tibial. The peroneus longus, which is so constant, winding round the outside of the knee, and extending into the perforating flexor of the middle digit, may rarely have no digital extension (Crax); Peroneus brevis is variable; present in the Albatross, Eagle, Rhea, Heron; but absent in the Stork and Pelican.

Among the forelimb muscles, the infraspinatus is the most variable in its presence, the muscle usually called such being the teres major; it is small, distinct, and ribbon-like in Lophophorus, Crax, Ithaginis, and Sula; absent in Tetrapteryx.

The homologues of the shoulder muscles in birds can only be determined with accuracy by a study of their nervous supply. Those of the hip muscles are little less difficult.

As Professor Selenka has, in his admirable part of Bronn's Thierreichs, figured the brachial plexus of a bird, I have endeavoured to do the same for the lumbar and sacral plexus of *Tetrapteryx Stanleyanus* in the woodcut on next page.

LUMBAR AND SACRAL PLEXUS OF *Tetrapteryx Stanleyanus.*



X.– THE PRESENCE OF A LACHRYMO-JUGAL SUTURE IN A HUMAN SKULL, AND ON ITS COMPARATIVE ANATOMY. By A. MACALISTER, M. B., Professor of Comparative Anatomy, Dublin University. (With Plate 1.)

[Read November 9th, 1874.]

THE relation of the processus maxillaris of the jugal bone to the supraorbital edge of the maxillary is subject to a considerable amount of variety. In the largest number of ordinary European crania this process ends at a point vertically over the infra-orbital foramen, or over the space between the first and second premolar tooth. The following Table shows accurately the relationships of this process, as noted in connexion with collateral points in 204 skulls:—

	End of Proc. Max. over Infra-orbital F.	External to Infra-orbital Foramen.	Internal to Infra-orbital Foramen.	Over 1st Premolar Tooth.	Over space between 1st and 2nd Premolar Tooth.	Over 2nd Premolar Tooth, or behind it.
Indo-Germanic Skulls	93	24	10	7	14	7
Turanian "	5	0	1*	—	—	—
African "	10	18	0	—	—	—
Australian "	0	10	0	—	—	—
American "	9	17	0	—	—	—
Polynesian and Malay "	1	11	0	—	—	—
TOTAL	118	80	11	7	14	7

In only one skull of all those examined have I seen the arrangement referred to in the title of this Paper. The specimen is a male British (?) skull which I found in the Museum of the Dublin University. There is no history of the specimen, which is numbered 29 in the collection, and which, in the late Dr. Ball's manuscript catalogue, is marked "Skull purchased.—J. Abell's." The skull is a strongly marked one, with prominent supra-orbital ridges, having on the left side a supra-orbital foramen, and on the right a groove. From these pass upwards and outwards, on each side, deep grooves, wherein lie the supra-orbital nerve and artery, and this vessel, on the left side, seems to have ended by dipping into the bone. The nasal bones are very large and prominent, and there is a high Wormian bone on each spheno-parietal suture. The exoccipital, on its lower side, sends out flat, paracondyloid spurs on each side, which overlap the groove for the occipital artery; but they have no cartilage encrustations, as in the case described by Uhde (Archiv für Klinische Chirurgie, viii. 1). The alisphenoid has on each side a foramen in the middle of its temporal crest. The processus tubarius of the ento-pterygoid (Rebsamen, Monatschrift für Ohrenheilkunde, 1868, No. 3) is unusually extended as a thin lamella, backwards and outwards, and projects sharply on the lower surface of the hinder accessory root of the great wing. The side of the spina angularis completes the articular cavity for the mandible which it has touched. The palatine surface shows some irregularity of suturation; the left horizontal

* A Japanese skull, with an approach to the arrangement here described, but the hamulus lachrymalis is very short, and hence there is 0·25" between the malar and jugal bones.

plate of the palate at the median suture is only three lines long, from before backwards, while the right exceeds four lines. There is also a trace of premaxillo-maxillary suture on this aspect. The ethmoidal spine of the sphenoid is trefoil-shaped, with two alæ minimæ (Luschka). There is a carotico-clinoid canal on the right, but only a stumpy middle clinoid process on the left.

The right malar bone has an exceedingly long maxillary process extending as far as over the canine tooth, and four lines internal to the infra-orbital foramen. The root of the process is slightly concave below, excavated for the orbital head of the levator labii superioris. Its anterior end is separated from the outer hamulus of the lachrymal bone by a slender isthmus of the margo-lachrymalis of the maxilla 0·7 of a line broad. This margin directly behind the tip of the malar has a transverse suture and a small foramen. On this side there is no sutura infra-orbitalis transversa, but the nasal process of the maxilla has an oblique vascular groove. The malar is excluded on this as on the left side from forming the anterior boundary of the spheno-maxillary fissure, as there is a sphenoidal process of the maxilla. On the left side the processus maxillaris is still more extensive, and stretches over the whole infra-orbital edge of the maxilla; crossing the margo-lachrymalis to join internally the end of the crista lachrymalis, it bridges over an imperfect sutura infra-orbitalis, and stretches in front of the large external hamulus of the lachrymal bone, with which it forms a suture of about a line and a half in length. The lachrymal and malar thus form a complete belt, excluding the maxilla from forming any part of the brim of the orbit. (Plate 1, fig. 1.)

As will be seen from the Table, such an extreme case of inward extension seems to be unique; at least I know of no record of such a condition.

Turning to the comparative anatomy of the processus maxillaris, we find that in the anthropoids the processus does not extend even as far inwards as in man. In the Gorilla (3 skulls) the process falls short of the infra-orbital foramen. In the Orang (1 skull) it falls still farther short. In the Chimpanzee (1 adult and 5 young skulls) it also falls short. In Hylobates Siamanga (1 sp.) it extends to the level of the foramen. In Inuus, Cercopithecus, &c., it falls short considerably, or else stretches nearly to the level. The only one of the Quadrumanous Primates wherein I found a lachrymo-jugal suture present was a Rhesus, species unknown, in which the large lachrymal bone forms the entire circumference of the depression for the lachrymal sac, and the long square malar sends in on each side a processus maxillaris to articulate with the edge of the former. (Plate 1, fig. 2.)

Among the Platyrrhines there is no trace of such a suture in Cebus, Mycetes, Ateles, or Callithrix. The Marmosets (Hapale) have the short wide processus maxillaris far from the lachrymal, and among the Lemurs there is no union or lachrymo-jugal contact in Tarsius, Lepilemur, Stenops or Lemur.

Among Chiroptera there is no lachrymo-jugal suture in any genus which I have examined. I have failed to find it in Chiromys and Galeopithecus, as well as in the other Insectivores.

Among Carnivores and Cetaceans no such suture exists; and, in the order Rodentia, the lachrymal bone shows a facial as well as an orbital surface; but the zygomatic process of the maxillary, which in these is largely developed, intervenes, and no suture occurs in any form.

In the allied order Proboscidea the lachrymal is small, ento-orbital, with a tubercle; but the small malar does not reach near to it. In Hyracoidea the lachrymal is similarly arranged.

Among Ungulates the Rhinoceros has the suture very distinct, superficial. The Tapirs have a very well marked but shorter suture. The Horses are similarly but more fully provided.

All Artiodactyles have an extensive facial surface of the lachrymal, and a long lachrymo-jugal suture; largest, proportionally, in the Bovidæ, smallest in the Deer.

Tylopoda possess a similar suture, but usually shorter and narrower.

In the Pigs the same arrangement obtains, the suture being largest, proportionally, in the Phacochoerus, smallest in the Peccaries. In the Hippopotamus the large, thin-walled lachrymal bone unites by a moderately extensive suture, and sometimes anchyloses to the malar.

Among the Sirenia the large rough malar rests internally on the scale-like, small, imperforate lachrymal in the Manatee, or on the cubical, solid lachrymal in the Dugong.

In Myrmecophaga the slender malar styles have a wide lachrymo-jugal suture; indeed, this is the chief attachment of the malar bone. The Pangolin (Manis and Pholidotus) have the lachrymal fusing so early with the maxilla as to be lost in distinctness; but in young skulls the lachrymal is well above the level of the imperfect zygoma.

Armadillos have a very distinct and wide union of this bone, and the large lachrymal in Orycteropus expands on the face for a considerable extent. Bradypus has a distinct lachrymo-jugal suture, as also is the case in the two species of Cholœpus and in Chlamydophorus. The lachrymal bone in Sarcophilus has a distinct lachrymo-jugal union. In Thylacinus it is not so large, but arranged as in the former. Phascolomys, Didelphys, Macropus, Petaurus, Phalangista, Halmaturus, &c., all agree in the presence of such a suture.

In my skulls of the Monotremes, Echidna and Ornithorhynchus, sutural marks have been obliterated, but in Ornithorhynchus I think I see traces of such lines, indicating a lachrymo-jugal contact.

Thus among Mammals the suture is present in all below the Hyracoids, absent in all above. In man there is even less tendency towards its occurrence in lower and aboriginal races than in the higher; thus in the Veddahs, Negroes, Esquimaux, Fuegians, Australians, the maxillo-jugal suture is much more vertical than in the skulls of more civilized races, and the termination of the malar is almost invariably external to the infra-orbital hole in all these.

XI.—On two New Species of Pentastoma. By A. Macalister, M.B., Professor of Comparative Anatomy, Dublin University. (With Plates 2 and 3.)

[Read November 9, 1874.]

In dissecting a specimen of *Boa imperator* brought home by Dr. Armstrong (of the Army Medical Service) from South America, I found in the lung and peritoneal cavity about six specimens of a Pentastoma. It resembles the P. *proboscideum* of Rudolphi, which has been found in the allied species *Boa constrictor* as well as in *Epicrates angulifer*, *Lachesis sp.*, and a species of Bothrops, but differs specifically from the type of *P. proboscideum*, as well as from the subtypical varieties of that species, *P. clavatum* of Wyman and *P. subcylindricum* of Diesing.

The specimens measure—the females 45-57*mm*, the males 19–22*mm* in length. In breadth the females are 3·3*mm* at the head, 1·27-2·28*mm* at the narrowest point which is the hinder fourth, and about 1·30–2·5*mm* at the tail. The males in width are a little less. The body is annulated posteriorly, but for the cephalic half the rings are not very clear; each ring consists of a wide flat belt of surface, with a slightly chitinized epidermis, and a thicker hypodermis, than that in the intersegmental zone. The head is convex, rounded posteriorly and flattened below; in front and below it projects forward as an anterior firm ridge, with a thick chitinous integument, a little under whose edge are the two pairs of hooks. The surface of the body is finely and rather irregularly ridged in some places, but is devoid of either processes or bristles. On the back of the vertex, 7*mm* from the front, there is a small, raised, flatly-conical, median wart, slightly radially ridged around its margin, but imperforate; in front of this are five or six other smaller wartlike surface-eminences.

The two pair of hooks are sharply curved, acute, hollow, the internal cavities extending to near their points: they have each an inferior basal spur, elongated anteriorly for muscular attachment; each has also a bilaminar basipodal process, to which also the muscular lamellæ are attached. These hooks are dark brown, and finely longitudinally striated in some places; each hook is about 0·6-0·28*mm* in length.

The mouth is elongated, elliptical, with a smooth chitinous peristomial ring, on the level of the bases of the median hooks; it leads into the scarcely subdivided digestive tract. The œsophagus is thin-walled, with no proper glandular wall, other than its thin lining epithelium; it passes over the receptaculum seminis, and between the two cirrus pouches. It dilates feebly into the stomach, an elongated sac with longitudinal glandular ridges on its wall, and here and there papillary processes. The gland cells are spheroidal, deep brown in colour, and give the digestive canal a deep hue, rendering it visible through the body wall. The lowest part of the digestive canal, or the intestine, is nearly colourless, thin-walled with slight ridges, slightly dilated before its anal end, but with no accessory gland. The whole canal is nearly straight, and the anus is apical. The average diameter of the intestine is 0·6*mm*. In none of the specimens was it enclosed in the tortuosities of the oviduct, nor of the male accessory organs, but these lie on its ventral side. There is an outer connective coat feebly separable, and containing a few scattered stellate connective corpuscles; then a longitudinal muscular coat of striped fibres, but I could detect no trace of circular fibres, such as Dr. Harley found in *P. multicinctum*.* The mucous membrane has a thin structureless basement raised into the ridges, and covered with the surface stratum of glandular epithelium. There was no sign of a corpus adiposum in any of the specimens. In all the intestinal tract was empty or nearly so.

The body wall consisted of—1st, an outer structureless chitinous wall, which showed no traces of pore canals, nor stigmata. 2nd, a very fine and irregularly distributed hypodermis, containing cells with branched processes. 3rd, a thick longitudinal stratum of striped fibres; and mixed with the deeper layer of this, and within it are, at the extremities, circular fibres. The body cavity within this is lined by a soft reticular membrane, but I could not detect the pavement epithelium within, which Harley noticed.

The nervous system consists of a bilobed epipharyngeal nerve ganglion sending down two longitudinal nerve cords parallel to the digestive tubes. These seem to send off branches into the body walls, supplying the muscles. I saw no trace of a hypopharyngeal ganglion, nor of the double ganglion described and figured by Blanchard in *P. proboscideum*. There was no trace of a metameric series of ganglia. There is no heart nor circulatory system, but a milky corpusculated fluid lies in the perivisceral cavity. There is no respiratory system, nor trace of tracheal tubes, so the breathing process is evidently dermal in site.

The hooks appended to the head have muscular bands inserted into their basipodal processes. Each hook has also a fan-shaped depressor muscle, which is only a specialized part of the longitudinal muscular layer of the body wall. Other fibres from the same source, but forming with them an angle of 55°, serve for the elevation of the hooks.

The reproductive organs are the only complex structures in these animals. In the female there is a vulva situated immediately in front of the anus; sometimes these orifices are so close together, that they appear to have a common integumental lip around them, but usually the vulva has a slightly protruding lip of its own. From this ascends a slender vagina of 6–12*mm* in length, ending in the slightly dilated fusiform uterus, which measures 25–30*mm* in length, and 3*mm* at its widest point. This is thin-walled, and ends above in a narrow oviduct which ascends at first directly nearly to the head, and there turning backward twists on itself, forming a long tortuous closely coiled tube, about

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* Proceedings, Zoological Society, 1856, p. 115.

six times the length of the entire body (not ten times as in *P. multicinctum*). This tube, like the uterus, is transparent, whitish when empty or faintly cream-coloured when filled with eggs, contrasting thus strongly in colour with the dark brown digestive tract. It has a thin basement layer, a very thin muscular coat of mixed circular and longitudinal fibres, not in separate laminæ, and these fibres are striped (not smooth as Harley found them in P. *multicinctum*). The tortuous tube in some of the females was so full of eggs as to distend the entire body, so that on a section being made, the whole perivisceral cavity appeared full of eggs. In one specimen, at least 16,500 eggs existed.

The tortuous oviduct, when traced back to its origin, begins as a fine tube attached to the medio-ventral wall of the body; at the second distinct ring behind the mouth, and on each side of it, is a roundly ovate sac, full of spermatozoa and granules. The former are arranged in bundles or spermaphores, but with no traces of thickened cases. These sacs have a thin proper wall, and open directly into the oviduct at its commencement. This commencement is really the point of coalescence of two fine tubes; the ovarian tubes, which arise from the cephalic end of the ovary, and running a short course, end by uniting between the ovate *receptacula seminis* to form the oviduct. The ovary is a thick-walled single tubular gland, extending from near the tail to the head, containing material which posteriorly appears simply granular, but which nearer the ducts becomes more differentiated into rounded or oval masses attached to a central axis.

The smaller males have a still more highly complicated apparatus. This organ consists of a large bilobate testis stretching on the dorsal wall of the body cavity as far as the tail, and lying over the alimentary canal. Its duct or vas deferens appears at the upper end of the gland, runs backward towards the tail for a very short extent, and then turns forwards again looping under the duct of one of the accessory glands. The vas deferens then divides into two lateral branches, right and left, which pass outwards and forwards, each ending in an intromittent organ. The divided extremity of the vas deferens is known as the annular canal whose relation can be seen in Plate 2, fig. 6. Into each limb of the annular canal posteriorly there opens an accessory gland. These are long, tortuous, tubular glands placed one on the right and one on the left, ventrad of the testis, thick-walled and lying one on each side of the vas deferens. The right of these crosses over the loop of the vas. These glands secrete the glutinous material which unites the filamentary spermatozoa into spermaphore clusters. The concavity in front of the annular canal is occupied by two lateral elliptical pouches, contiguous in the mesial line, lying under the digestive tract, and opening on the surface ventrally in front; these are the cirrus pouches which contain the intromittent organs. These are tubular, the prolonged extremities of the vasa deferentia, and are nearly equal in length to half the animal's body. Each of these having preserved a uniform calibre for most of its extent, ends by suddenly dilating, then narrowing to a fine point; by these organs the spermatozoa are conveyed upward on their long journey to the spermaphores of the female.

As anterior diverticula from these are two lateral thick-walled sacs each lined with a ridged and processed chitinous membrane. These accessory sacs are hollow, and their chambers communicate with each other by a transverse, anterior, annular canal over the œsophagus. The use of these sacs is unknown. These cirrus pouches and their accessory parts are much larger than in *P. tænioides*, where these organs are small and limited to lateral areas beside the chitin sac-organs.

The ova were found in several stages of development in some of the females, from the perfectly undeveloped egg with germ-spot and vesicle to the bi or multipartite cleft yelk of the fertilized egg. In some of the latter the spherules were very disproportionate in size, some six times the size of the others, and the larger always had a tendency to one side or surface of the ovum. The eggs are holoblastic, and segmentation ends in the formation of a blastoderm. There are polar groups of cells visible in some ova and a trace of primitive streak, subdividing the tail end of the egg into two lateral parts. When the body forms as a granular mass six lateral lobules project downwards and outwards, two of which unite to form the basis of the antennary jaws of the head, two form the larval forelimbs, and the hindmost pair form the hind legs. The first and second pair of these form first, the hindmost afterwards. In several of the hundreds of ova which I examined I saw a faint trace of annulation, one or two transverse furrows, indication of a metameric growth. In one embryo which is obliquely shown (Plate 3, fig. 11) these are indicated (and rather exaggerated), and two of the limbs are shown, armed with paired claws. In the earlier stages before the claws appear the knobs look like the parapodia of worms, but a middle transverse joint in each of these limb knobs is indicated in some of my specimens. Two free embryos further developed than any of those enclosed in the egg membranes are shown Plate, figs. 12 and 13. In these the larval form is easily recognisable. In no stage nor specimen did I see a trace of the simple salivary gland which exists in *P. tænioides*.

The adult hooks are not the descendants of the embryonic limbs, but seem to indicate segments anterior to the three limb-bearing segments of the larva. The extremely complex subsequent-developmental stages I had no means of investigating.

In the above observations I have refrained from quoting from the classical memoir of Leuckart on the Pentastomidæ, our chief source of information on these aberrant arthropods, as I wish to make this Paper only a record of direct observation.

We may summarize the specific characters of this species thus: *Pentastoma imperatoris*, body with 40–45 rings, clearly annulated behind, more indistinctly in front; head acutely wedge-shaped with no lateral stigmata, but with several median dorsal warts; hooks simple with slender basal processes; vulva very close to the vent; posterior end dilated pyriform, with its narrowest end terminal; stomach scarcely dilated; males slightly incurved at the tail; dimensions as above.

The other species, *P. Aonycis*, of which I have only obtained two specimens, both females, occurred in the peritoneal cavity of the large Indian Otter from the river Indus (*Aonyx leptonyx* var. *Mayoii*) sent home by the late Earl of Mayo to the Dublin Zoological Gardens (whose anatomy I have described in the Proceedings of this Academy, Vol. I. Series II., Science. p. 539). These parasites measured 17-20*mm.* in length, and were straight, elongated, acuminated, with nearly conical apex and an obtusely truncated head which is 25*mm.* in width. It is closely annulated with 30 rings, each of which is sharply defined and separated from its neighbours by a sharp-edged, square-profiled furrow. These rings, from being very wide (0·7*mm.*) posteriorly, become very narrow in front and cease to be distinct at the head. The mouth has two lateral chitinous lip-ridges, one on each side. The two pair of hooks are elongated, acute, with longer basal fulcra than in *P. imperatoris* (four times the length of the exserted portion of the hook), but with a much shorter basal process. There is a single bilobed epipharyngeal nerve ganglion, and the oviduct, ovary, and digestive tract are arranged on the same plan as in *P. imperatoris.*

The surface of the skin is covered over with numerous, irregularly arranged circular dots with depressed edges; these are most numerous about the head aud forepart, but become fewer posteriorly. There were no ova in any forward state of development.

XII.—On the Muscular Anatomy of Cholœpus Didactylus. By H. W. Mackintosh, B. A. (With Plate 4.)

[Read November 9, 1874.]

In the month of January last, Professor Macalister having purchased* a fine specimen of *Cholœpus didactylus* from Mr. Gerrard of London, kindly afforded me the opportunity of studying its anatomy. Notwithstanding the peculiar habits of this animal, it does not seem to have received much atteution from myologists. The fullest description is that of Professor Humphry (Journal of Anatomy and Physiology, November, 1869), and even that is incomplete in many points, which, however, is easily accounted for from the fact of many of the muscles having become decomposed; Mr. Galton, in his Paper on Dasypus (Transactions of the Linnean Society, XXVI.), mentions four of the muscles, and Professor Meckel is stated by Professor Humphry to have alluded to the muscular anatomy of this animal, but I have not been able to corroborate this. With a view to supply this defect as far as possible, we made a thorough examination of our specimen, and were surprised to find in it many points of difference from its congener Bradypus, although the identity of

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* Out of the grant of money given to him by the Council of the Royal Irish Academy for procuring specimens for examination.

habits of the two creatures led us to expect a close correspondence in the arrangement of their muscles. The weights of most of the muscles are given in decimals of an ounce, in a tabular form at the end of the Paper (*vide* p. 78).

In the head, we noticed the Eustachian tube opening as an oblique pit just in front of the external pterygoid, and placed in front of it was a distinct depression leading upwards, the termination of which we endeavoured to find, but in vain, and hence were unable to surmise its function. The mucous membrane of the cheek was studded with rows of papillæ; the parotid and submaxillary glands were united, but no trace of a sublingual existed. Other points of interest in general anatomy were—the well-developed condition of the stylomaxillary fold of fascia, which extended along the whole length of the hyoid arch; the very strong spinoglenoid ligament; the well-developed condition of the ligaments of Flood and Humphry; a remarkable fibrous band passing from the front aspect of the humeral trochanter to the anterior ulnar attachment of the orbicular ligament; the very deep supraolecranal pit in the humerus; the limited degree of rotation of the radius (one-fifth of a circle); the absence of the round ligament of the hip joint, as is usual in sloths; the strong mucous ligament of the knee joint; and the curious arrangement of the ligaments in the ankle joint. Of these the external lateral extended from the fibula in three slips, an anterior attached to the outer tubercle of the astragalus, a middle attached to the body of that bone, and a posterior to the calcaneum, a deep slip of which dips into the base of the astragalus; a large number of fibres extend between these two bones and form an astragalo-calcaneal ligament; the internal lateral is strong and thick, running from the inside of the internal malleolus to the astragalus; the anterior ligament is weak.

The principal muscles of the head were:—

Massetericus clothes the descending process of the jugal, and becomes fused near its insertion with temporalis, which was normal.

Buccinator had its fibres running mainly in an anterior direction.

Zygomaticus arises from the front of the jugal process.

In the neck and trunk we found the following arrangements:—

Splenius, with an occipital insertion, has its origin from the transverse processes of all the cervical vertebræ, and from the front of complexus, which has a similar cervical origin, but includes the first dorsal also, and is inserted into the occiput.

Longus colli is remarkable only for its strength.

Obliquus colli superior arises from the transverse processes of the four upper cervical vertebræ, and is inserted into the front of the atlas, whilst its inferior part extends from the first three dorsals to the transverse process of the seventh cervical.

Rectus colli stretches from the second and third dorsals to the atlas.

Rectus capitis anticus major was curiously arranged, taking origin from the three upper dorsals and four lower cervicals, and being inserted into the basioccipital.*

Rectus capitis anticus minor extended from the transverse process of the atlas to the lateral ridges of the same bone, close beside the insertion of major.

Rectus capitis posticus major and minor were both normal in their attachments, but feebly developed, the latter being the stronger of the two.

Rectus capitis lateralis was moderately strong.

Obliquus capitis inferior was enormous, a condition, probably, to be correlated with the necessity for combined lateral and downward motion of the head.†

Scalenus medius, with scalenus posticus inseparable from it, arises from the transverse processes of all the cervical vertebræ except the atlas, and is inserted into the first and second ribs, some of the fibres belonging to the former being continuous with the fibres of origin of rectus thoracicus lateralis, which from this origin passes down to be inserted into the eighth and ninth ribs; it is placed anteriorly to serratus magnus and externally to rectus abdominis, which is inserted into the fifth, sixth, seventh, and eighth sternal ribs, and has its fibres directed upwards and slightly outwards, overlapping the normal internal intercostals.

Sternocostalis arises from the presternum and four upper mesosternal sternebræ, and is inserted into the second, third, fourth, fifth, and sixth ribs.

Iliocostalis sends a tendon to every rib, and has a cervical prolongation, as has longissimus dorsi, which is very large.

Serratus posticus inferior arises from the lumbar fascia, and is inserted into the ribs, from the thirteenth to the twenty-third inclusive.

Sternomastoideus and cleidomastoideus are curiously related to one another; they are both inserted into the paramastoid process, separated only by the spinal accessory nerve; the former arises from the anterior surface of the sternum, and from the mesoscapular segment between the clavicle and the sternum. On its way upward it detaches a slip from its hinder border, which runs into the cleiodomastoid (origin middle of clavicle), which in turn gives off a slip to the superior trapezius.

Thus it will be seen that both muscles are distinctly represented here, the only trace of union being the transverse band. In Arctopithecus a single muscle exists arising from the sternum, but betraying its compound nature by its two slips of insertion into the paramastoid; in Bradypus there is manifestly a sternocleidomastoid, for here the origin

* A somewhat similar, but more restricted origin (sixth, seventh, and eighth cervicals) exists in *Arctopithecus Blainvillei*. *Vide* Proceedings Royal Irish Academy, Vol. I., Series II. (Science), page 519.

† This muscle was also well developed in Arctopithecus (*loc. cit.*).

is from sternum, first rib, and clavicle. Unfortunately this muscle was destroyed in Professor Humphry's specimen, so that we were unable to determine whether the above peculiarity was an individual or a generic one. There was no trace of the slip from the cleidomastoid to the trapezius in either Bradypus or Arctopithecus.

Omohyoideus was absent, and trachelo-acromialis (omo-atlanticus of Professor Haughton), though it shares the same fate in Bradypus and Arctopithecus, is represented in Cholœpus by a very slender band of muscle arising from the paramastoid process, and inserted, not into the acromion process of the scapula, but into the fascia over the supraspinatus muscle in front of the insertion of the occipital rhomboid.

Sternohyoideus and sternothyroideus were separate from one another (as in Bradypus, but not as in Arctopithecus), the former arising from the presternum and first rib, the latter from the presternum alone, underneath the sternohyoid, which is inserted into the tendinous inscription of the digastric fusing with its anterior portion; the sternothyroid is inserted as usual into the side of the thyroid cartilage.

Digastricus, which, as in Arctopithecus, only merits its name from the tendinous inscription placed opposite the angle of the mandible, arises from the stylohyal bone (tympanohyal in Arctopithecus), and is inserted into the lower jaw as usual.

Mylohyoideus extends along the whole length of the mandible.

Geniohyoideus is normal.

Hyoglossus runs from the ceratohyal and thyrohyal to the tongue, and styloglossus to the same organ from the former of those two bones.

The muscles in connexion with the Fore limb were arranged as follows:—

Trapezius was with difficulty separable into superior and inferior portions; the former, which included the clavicular segment as well, arose from the middle line of the neck and from the occiput, and was inserted into the lower border of the scapular spine as far down as the origin of deltoid; the inferior part extended from the four upper dorsal spines to the spine of the scapula.

Rhomboideus is divisible into three parts, (a) major, arising from the two lower cervical and three upper dorsal vertebræ, inserted into the whole vertebral edge of the scapula, and completely covering the small thin (b) minor, which extends from the sixth and seventh cervical vertebræ to the scapula opposite to the spine; (c) occipital, quite separate from the other two, arising, as its name imports, from the occiput and inserted into the superior angle of the shoulder blade.*

Teres major is a large muscle which arises, as usual, from the scapula, and has the normal humeral insertion separate from, but close to the attachment of latissimus dorsi, which has an extensive origin from the spines of the third, fourth, fifth, sixth, and seventh dorsal vertebræ,

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* This portion was absent in Arctopithecus and Bradypus.

from the eleventh, twelfth, and thirteenth ribs, and from the lumbar fascia.

Teres minor is inseparable posteriorly from infraspinatus.

Pectoralis minor is not represented, but its absence is compensated for by pectoralis major, which consists of three parts; the first of these arises from the presternum, and is inserted into the pectoral ridge, which occupies about the upper two-fifths of the humerus; the highest fibres of origin are the lowest fibres of insertion, and the whole humeral attachment is about four times as long as the sternal; the second, or bicipital part, arising from half an inch of the sternum below the last, runs parallel to it, and is inserted into the inner border of the flexor of the forearm, opposite the level of the supracondyloid foramen; the third segment, arising from the whole length of the sternum, is composed of two laminæ, the superior being inserted underneath the attachment of the first part, and equalling it in length, the deeper layer going to the outer part of the head of the humerus and to the capsule of the shoulder joint, with the anterior thoracic nerve crossing its upper border and distributed to its superior aspect. No trace of this remarkable arrangement seems to exist, either in Bradypus or Arctopithecus, for the great pectoral in both is merely bilaminar, not even presenting the presterno-humeral slip, though in the latter genus the deep lamina of the third part sends a slip to the capsule of the shoulder joint. It will be interesting to know if the curious insertion of the second part be constant in Cholœpus; Professor Humphry was not able to determine its arrangement in his specimen.

Pectoralis quartus (brachio-lateralis, Professor Humphry) arises from the eighth, ninth, tenth, and eleventh ribs, and is inserted into the head of the humerus.

Coracobrachialis presented both the long and short varieties, the former arising from the coracoid process and being inserted into the inner edge of the humerus, behind the supracondyloid nerve; the latter, with a similar origin, is inserted into the humerus, below and behind the tendons of latissimus dorsi and teres major. Mr. Galton describes it as being thin, cord-like, and of uniform size, but does not say to which variety it belongs.

Subclavius extended from the first rib to the inner border of the sternal end of the clavicle and to the acromion process, as was also the case in Mr. Galton's specimen.

Deltoideus is divisible, as usual, into three parts: scapular, acromial, and clavicular; the first and largest of these arises from the spine of the scapula, and is inserted into the deltoidal crest on the humerus; the second part arises from the acromion process and outer border of the clavicle, and is inserted into the radius along with the superficial part of the biceps; the third has a similar origin to the second, and is inserted along with, but free from, the first. Here again we have a considerable difference from the arrangement in Aï, where the muscle is not tripartite at all, though in Arctopithecus it supplies an accessory head to the biceps.

Supraspinatus, infraspinatus, and subscapularis presented no features of interest, except that the weight of the latter equalled the combined weights of the two former; a nearly similar condition occurred in Arctopithecus.

Subscapulohumeralis was very long and quite distinct.

Serratus magnus, which had no separate levator scapulæ portion, arose from the upper six and from the eighth ribs, as well as from the three lower cervical transverse processes, and was inserted into the scapula, as usual.

Biceps humeralis is a curious muscle, but by no means so complex as in Arctopithecus. It has a simple, long tendon of origin from the scapula, which expands into two bellies, the superior of which joins the acromial deltoid, and is inserted into the tubercle of the radius, as usual; the deeper segment is inserted into the coronoid process of the ulna, along with, and inseparable from, brachialis anticus, which arises from the outer aspect of the humerus external to the insertion of the deltoid, and extending half-way up the bone. This arrangement appears to present us with another variety in the already numerous modifications of attachment of biceps in the Edentata.

Dorso-epitrochlearis (Tricipiti accessorius) is a large muscle arising, as usual, from triceps, and inserted entirely into the supracondyloid process. Mr. Galton describes it as being thin, cylindrical, rolled on itself, and inserted chiefly into the anterior ridge of the supracondyloid foramen, but slightly into the humerus above the foramen and below the insertion of coracobrachialis; there was no forearm prolongation.

Triceps longus, externus, and internus, are all normal, their heads being more or less fused.

Anconeus externus is small, and can only be artificially separated from triceps longus, and anconeus internus (epitrocles-anconeus) is in the same condition with regard to its insertion, though quite distinct at the origin. It was present in Mr. Galton's specimen, but is not described.

Pronator radii teres had a similar origin in our specimen and in Professor Humphry's, viz., above the internal condyle of the humerus, but the insertions differed considerably. Professor Humphry found it to be attached to the lower end of the radius opposite to the insertion of supinator longus, whereas, in our specimen it fused with the lower part of that muscle, which consists of two parts—a superficial which arises from the deltoid, but is distinguished from it by a tendinous inscription, and was inserted into the fascia of the front of the wrist, and a deep segment which is enormously developed, arising from the humerus outside the musculospiral ridge and extending as far down as the condyle, and inserted into the radius for the lower four-fifths of its length. Professor Humphry's specimen resembled ours in being double, in the insertion of the superficial portion, and the origin of the deeper; he describes the origin of the former part as being high up on the humerus, not from the deltoid, whilst the insertion of the deeper segment was into the end of the radius, much as in man; this arrangement agrees more closely with that found in Arctopithecus than it does with the condition in our specimen.

Pronator quadratus has a broader attachment to the ulna than to the radius, the reverse apparently obtaining in Professor Humphry's specimen, though it is not quite clear whether his description refers to Unau or to Aï.

Flexor carpi radialis extends in both specimens from the inner condyle of the humerus to the scaphoid and flexor digitorum profundus and sublimis, and palmaris longus presented the same features in the two. The two latter muscles are fused for the upper part of their course, but near the distal end the former of the two becomes separate as a small muscle ending in two tendons to the two digits; the main part of the muscle ends also in two tendons to the digits. The first named of the three is quite distinct, arising from the outer condyle of the humerus, from the forearm bones, and from the tendons of the radial and ulnar flexors of the wrist, as well as from the tendon of palmaris; it also sends two tendons to the terminal phalanges of the digits.

Flexor pollicis longus was not represented in our specimen, and Professor Humphry makes no mention of it.

Flexor carpi ulnaris is a curious muscle, consisting of two parts; the upper one of these arises from the back of the internal condyle and from the hinder border of palmaris (?), becomes tendinous at the middle of the forearm, and is inserted into the outer border of the radius posterior to and confluent with the insertion of supinator longus, and covering over the attachment of extensor carpi radialis; it is also inserted into the fascia of the back of the forearm; the deep part, which appears to be the normal ulnar flexor, arises from the olecranon, from the lower border of anconeus, and from the whole inner edge of the ulna, and is inserted into the pisiform bone. Professor Humphry also describes it as consisting of two parts, but the upper one, whilst in the main agreeing as to its origin with the foregoing description, becomes fused with supinator longus, and is inserted into the palmar fascia, pisiform, and margin of the ulna.* The deep part had the same arrangement as in our specimen. The separation into two parts of this muscle in Cholœpus is foreshadowed in the Three-toed Sloth, where the origin is bicipital and the two parts remain separate for a long distance, but there is no tendency to union between it and supinator longus.

Supinator brevis is large, inserted into the upper one-third of the radius, and pierced by the posterior interosseous nerve, which forms much the larger part of the radial nerve.

Extensor carpi radialis is single, arising from the outer humeral condyle and from the radius, and ending in two tendons, one being attached to the upper two-thirds of the second metacarpal bone, and the other to the proximal end of the third metacarpal. Professor Humphry

* It is possible that this may be a clerical error, as the ulnar attachment of sup. long. is not mentioned by Professor Humphry.

only found the condylar origin, and the insertions of both tendons was into the proximal parts of the metacarpals.

Extensor digitorum longus presented no feature of interest, extending from the outer condyle and from the ridge on the back of the radius to the terminal phalanges of the digits. The radial origin is not mentioned by Professor Humphry.

Extensor minimi digiti (auricularis) arises from the intermuscular septum on the back of the forearm, being traceable as far as the upper third; the tendon runs through a separate sheath in the annular ligament, expands on the ulnar side of the third digit, and joins the tendon of the long flexor. This muscle is not described by Professor Humphry.

Extensor carpi ulnaris arose in both specimens from the external condyle, olecranon and ulna, and divided into two parts, one of which becomes tendinous and is inserted into the proximal dorsal aspect of the first phalanx of the third digit; the second segment, which is in fact an ulnaris quinti, ends in a tendon which joins that of the extensor of the little finger at its insertion. In Professor Humphry's specimen the muscle ended in two tendons running to the third and fourth digits.

Extensor ossis metacarpi pollicis (extensor pollicis primus) arose in both from the greater part of the posterior surface of the ulna, and was inserted into the trapezium.

Extensor secundi internodii pollicis was absent.

Extensor indicis was normal, running in both animals from the middle of the ulna to the rudimentary second digit.

Interossei are arranged somewhat similarly in both. In our specimen the first and second act as abductor and adductor annularis, respectively; the third placed between the third and fourth metacarpals runs to medius; the fourth and fifth between the second and third metacarpals go to medius and index, respectively; the sixth, which is bicipital and placed between the first and second metacarpals, goes to index, whilst an additional one, which does not seem to have existed in Professor Humphry's specimen, extended from the pisiform bone to the ulnar side of the second metacarpal.*

Lumbricalis single, arising between the tendons of flexor digitorum, divides into two parts, one going to the radial and one to the ulnar side of each digit, the latter attachment apparently not existing in Professor Humphry's specimen.

We found a tendinous band passing from the tip of the rudimentary fifth digit to the first phalanx of the fourth.

* Professor Humphry arranges them thus:—One between Met. I. & II. to the radial side of the extensor tendon of digit II.; one between Met. IV. & III. to ulnar side of extensor tendon of digit III.; one between Met. II. & III. on palmar aspect passing to ulnar side of extensor tendon of digit II.; and one on the dorsal aspect to the radial side of the extensor tendon of digit III. There is also an adductor of digit II. from pisiform to ulnar side of first phalanx (which seems to represent the "additional" muscle mentioned above). There is also a second set of "phalangeal" interossei, two in number, from the apposed sides of the two second phalanges to the apposed sides of the two extensor tendons.

In the hind limb:—

Sartorius consists of two parts, primus and secundus; the former arises from the anterior superior spine of the ilium, and by a few fibres from the abdominal parietes, and is inserted into the inner side of the femur for the third one-fourth of its length; it is supplied by the external cutaneous nerve of the lumbar plexus. Secundus arises from the middle of Poupart's ligament and from the abdominal wall, and runs to the upper point of quadrisection of the tibia. This latter portion was not found at all by Professor Humphry, though his description of the former division agrees closely with the above arrangement. In Bradypus and Arctopithecus there is but a single origin, which, however, takes in both the parts above mentioned (ilium and Poupart's ligament), but the insertion is double, into femur and tibia, though the latter insertion did not exist in Professor Macalister's specimen.

Psoas parvus presents nothing remarkable, arising from the five lower dorsal vertebræ, and being inserted into the pectineal tubercle.

Psoas magnus is separable with difficulty from the normal Iliacus, and has a coextensive origin with psoas parvus.

Pectineus stretches from the pectineal tubercle to the upper half of the femur. The arrangements in Professor Humphry's specimen are substantially the same as these.

The three adductors are also normal and correspondingly arranged, primus being quite separate, secundus not divisible into two laminæ, and inserted into the middle of the femur, and tertius, extending from the horizontal ramus of the pubis to the lower point of trisection of the femur, or to the condyle, as in Professor Humphry's specimen.

Quadratus femoris is normal, agitator caudæ absent, as is the case also with obturator internus, but its non-appearance is compensated for by obturator externus, which consists of two parts, the upper arising from the horizontal ramus of the pubis near the acetabulum, the lower, which is penniform, taking origin from the whole obturator membrane, and both the inside and outside of the horizontal ramus of the pubis.

The gemelli are present and distinct.* Glutæus maximus is a fan-shaped muscle arising from the fascia over the side of the sacrum and of glutæus medius, and from the tuber ischii; it is inserted half way down the outside of the femur.

Pyriformis is very separate, arising from the front of the sacrum inside the pelvis, and inserted into the great trochanter, fused with that of glutæus medius, which arises as usual from the iliac fossa, and is overlapped by glutæus quartus both at origin and insertion.

Glutæus minimus exists as a very fine band crossing the back of the capsule of the hip joint, from the margin of the acetabulum to the great trochanter, underneath pyriformis. Glutæus quintus is

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* There was a double obturator externus in Arctopithecus, but a single one in Bradypus.

absent as is tensor vaginæ femoris, but iliocapsularis is present as a small muscle, extending from the anterior inferior spine of the ilium to the capsule of the joint. None of these muscles are alluded to by Professor Humphry.

Biceps femoris agrees with what appears to be its general condition among Edentata, in consisting of two parts, one, representing the normal muscle, arising from the tuber ischii and inserted into the head of the fibula, and upper third of the tibia, the other taking origin from the whole length of the femur, and inserted into the second and third fourths of the inner edge of the tibia. Professor Humphry found some fibres running from the latter portion to join semitendinosus and gracilis, while the rest of it formed a sheath for the calf of the leg, and was inserted into the edges of the two bones of the fore leg, a condition which approaches very closely to that obtaining in our specimen, as is shown in Plate 4,* which represents more particularly the relations of biceps to the double insertion of gracilis; the pannicle is also well seen running in behind the origin of iliacus.

Bicipti accessorius is absent.

Semimembranosus is large, running from the whole internal border of the tuber ischii to be inserted into the tibia, above the attachment of semitendinosus, which has no inscription (as was also the case in Professor Humphry's specimen), arises along with the ischial portion of biceps, and is inserted along with the inner half of gracilis, which consists of two parts arising in common from the symphysis pubis; the external portion is inserted into the internal aspect of the tibia; the second joins the ischial biceps, and is inserted into the fibula and fibular fascia, connected also with semitendinosus. In Arctopithecus this muscle is single, but the insertion embraces all the parts described above; in the specimen of Bradypus, dissected by Dr. Macalister, it was also single, but the insertion was only into the tibial condyle, whilst in the Aï, examined by Professor Humphry, the main details corresponded to the arrangement in Unau. A considerable degree of coalescence obtains in quadriceps extensor cruris rectus, being but slightly separable from the two vasti and cruræus, which are completely fused.

Popliteus is normal with a large fabella in its tendon of origin, with which in Professor Humphry's specimen soleus is connected by a thin muscular slip, the rest of the muscle arising from the upper part of the fibula; we could not find any trace of the former head, and the latter extended over the whole fibula; the insertion in both was into the calcaneum.

Gastrocnemius externus arises rather higher up than usual, has no fabella, and is inserted by two (?) tendons into the calcaneum; its tendon is crossed by that of gastrocnemius internus at the lowest point of

* Which is a *camera lucida* copy of Professor Macalister's *ad naturam* sketch. Similar arrangements exist in Arctopithecus, Bradypus, Manis, Cyclothurus, Myrmecophaga, Tamandua.

quinquesection of the leg, the latter tendon going to be inserted into the os calcis external to the former, and quite separate from it; the origin of internus is from the lower back portion of the femur and is devoid of a fabella. A similar arrangement is described by Professor Humphry, with the exception of the two tendons of insertion of externus.

Plantaris is not represented in either, though Professor Humphry, judging by the arrangement in Cyclothurus, seems to think that it is involved in gastrocnemius externus, and regards the popliteal slip of soleus as correspoding to the external portion of the gastrocnemius in Cyclothurus. It was largely developed in Arctopithecus.

Flexor digitorum longus and Flexor hallucis longus are fused, but divide into three tendons before reaching the ankle joint; one tendon goes to each digit and receives the tendon of the combined tibialis antious and extensor longus. Professor Humphry in his description of flexor digitorum says that it arises from the tibia, fibula, and slightly from the popliteal sesamoid, the tibial portion being deep and covered by the fibular part, as well as by tibialis posticus; the former of these represents the flexor of the fingers and the latter that of the thumb. The arrangement is more complex in Arctopithecus, where we find flexor digitorum existing as a tricipital muscle taking origin from the upper and back part of the tibia, from the middle of that bone, and from the greater part of the fibula and external lateral ligament of the knee, and receiving the tendon of plantaris; flexor hallucis arises from the fibula and interosseous membrane, and unites with it, the two subsequently dividing into three tendons. The first of these origins of flexor digitorum is alone described by Professor Macalister in Bradypus, and Dr. Humphry found in that animal that it consisted of three parts representing respectively plantaris, flexor digitorum, and flexor hallucis.

Flexor digitorum brevis arises from the calcaneum, and is inserted into the sheath of the flexor tendon of the middle digit. Professor Humphry found a totally different arrangement, for this muscle in his specimen was in three parts, one bicipital from entocuneiform and os calcis, the other two from os calcis; they all terminate in the sheaths of the flexor tendons.

Flexori longo accessorius is very large, arising from both sides of the calcaneum and inserted chiefly into the tendon of the outer toe; it was continuous with soleus in Professor Humphry's specimen.

Tibialis posticus is arranged quite differently in the two specimens. In ours it was perfectly normal, extending from the tibia to the entocuneiform; in Dr. Humphry's it consisted of two parts, the tendon of the larger of which runs behind the inner malleolus, sends a few fibres to the entocuneiform, but is mainly attached to the second metacarpal; the tendon of the smaller internal portion runs in a separate channel in the malleolus, and passing over the inner cuneiform, becomes continuous with a portion of the short flexor of the fingers, whose tendon blends with that of flexor brevis to the fourth digit. The arrangement in Aï agrees in the main with that in our specimen. Tibialis anticus and extensor hallucis occupy a very curious position; their origins, which are slightly separable from one another, extend down the whole front of the tibia. and the lower two-thirds of the anterior border of the fibula, and becoming perfectly fused in front of the leg; the tendon formed by the two bellies winds round the ankle joint and is inserted into the front of the flexor of the middle toe, thus converting these two powerful muscles into flexors. Here again Dr. Humphry's description, so far at least as the origin is concerned, differs largely from ours. He found the former of the two to consist of three parts, one arising from the upper half of the tibia, one from the middle of the fibula (extensor hallucis), and a third from the lower front part of the fibula and from the malleolus ; this latter crosses the ankle to be inserted into the entocuneiform bone and base of first metatarsal, but apparently quite separate from the rest of the muscle, whose two parts unite into a tendon which subsequently divides into three going to the flexor tendons of the three digits; the two latter segments appear to represent in their origins the entire fibular part in our speçimen, but we found no trace of the curious insertion of the third portion, nor yet of the threefold attachment of the tendon from the first and second. The tricipital origin also obtains in Arctopithecus and Bradypus, but the insertion is into the entocuneiform and metatarsals.

Extensor hallucis brevis is a small muscle extending from the lowest one-tenth of the fibula to the rudimental hallux.

Extensor digitorum brevis arises from the front of the tarsal bones, and its three tendons are inserted into the deep surfaces of the tendons of extensor longus. The origin in Professor Humphry's specimen included the proximal parts of the metatarsals, as well as the tarsals; the insertion was into the terminal phalanges of all the digits.

Transversalis pedis extended from the external metatarsal to the base of the first phalanx of the inner toe, to which Dr. Humphry adds a second insertion into the distal end of the first metatarsal.

Extensor digitorum longus is a small muscle sending one tendon to each of the three digits ; it supplied only the third and fourth digits in Professor Humphry's specimen.

Peronæus longus arises from the back of the fibula, and from the popliteal sesamoid in our specimen, and is inserted into the base of the fourth metatarsal, with slight attachments to the other three; peronæus quinti was absent, and we could find no trace of p. brevis, though it is described by Professor Humphry as extending from the malleolus to the base of the fifth metatarsal; p. tertius is well developed in both, running from the front edge of the fibula to the fifth metatarsal, with fibres to the fourth, as well as in Professor Humphry's specimen.

Abductor interni digiti in our specimen stretches from the internal plantar sesamoid to the sheath of the flexor tendon of the inner digit.

The interossei are well developed, but present no modification of any great importance, two being attached to each extensor, one on each side.

Table of Weights of Muscles of Cholæpus didactylus.

HEAD AND TRUNK.

Massetericus Temporalis	3·05
Digastricus	0·09
Splenius	0·06
Sternomastoideus	0·08
Cleidomastoideus	0.05
Tracheloacromialis	0·02
Sternohyoideus	0·09
Sternothyroideus	0·04

FORE LIMB.

Trapezius inferior		0·09
Trapezius clavicularis Trapezius superior		0·20
Rhomboideus major		0·13
Rhomboideus minor		0·03
Rhomboideus occipitalis		0·03
Teres major		0·13
Latissimus dorsi		1·24
Teres minor		3·05
Pectoralis major	presternohumeral	not weighed
	bicipital slip	0·12
	superficial 3rd part	0·51
	deep 3rd part	0·23
Coracobrachialis longus		0·02
Coracobrachialis brevis		0·01
Subclavius		not weighed
Deltoideus acromialis		0·20
Deltoideus scapularis		0·26
Deltoideus clavicularis		0·03
Supraspinatus		0·19
Infraspinatus		0·12
Subscapularis		0·31
Subscapulohumeralis		0·07
Serratus magnus, superficial		0·38
Serratus magnus, deep		0·11
Biceps brachii		0·08
Brachialis anticus		0·10
Dorsoepitrochlearis		0·16
Triceps longus		0·20
Triceps internus Triceps externus		0·37
Anconeus externus		0·02
Anconeus internus		0.03
Pronator teres		0·17
Supinator longus, deep		0·42
Supinator longus, superficial		0·05
Pronator quadratus		0·05
Flexor carpi radialis		0·05
Flexor digitorum profundus		0·75
Flexor digitorum sublimis		0 02
Palmaris longus		0·12
Flexor carpi ulnaris		0 06
Supinator brevis		0·08
Extensor carpi radialis		0·09
Extensor digitorum longus		0·07
Extensor minimi digiti		0·05
Extensor carpi ulnaris		0·09
Extensor ossis metacarpi pollicis		0·01
Extensor indicis		0·03

HIND LIMB.

Sartorius primus		0·26
Sartorius secundus		0·09
Psoas parvus		0·13
Psoas magnus		0·24
Iliacus		0·44
Pectineus		0·10
Adductor primus		0·18
Adductor secundus		0·17
Adductor tertius		0·17
Quadratus femoris		0·04
Obturator externus		0·23
Gemelli		0·04
Gluteus maximus		0·41
Gluteus medius		0·27
Gluteus quartus		0·10
Gluteus minimus		not weighed
Pyriformis		0·11
Iliocapsularis		0·01
Biceps femoris	ischiatic part	0·17
	femoral part	0·51
Semimembranosus		0·28
Semitendinosus		0·08
Gracilis	inner part	0·18
	outer part	0·20
Rectus femoris		0·23
Vastus externus Vastus internus Crureus		0·26
Popliteus		0·07
Solæus		0·14
Gastrocnemius externus		0·08
Gastrocnemius internus		0·19
Flexor digitorum longus Flexor hallucis		0·43
Flexor digitorum brevis		not weighed
Flexori longo accessorius		0·08
Tibialis posticus		0·07
Tibialis anticus Extensor hallucis longus		0·33
Extensor hallucis brevis		0.05
Extensor digitorum longus		0·08
Extensor digitorum brevis		0·08
Transversalis pedis		not weighed
Peroneus longus		0·06
Peroneus tertius		0·09

XIII.—ON RETRO-PERITONEAL CAVITIES. By GEORGE REGINALD LEEPER, Student in Medicine, Trinity College, Dublin. with Plate 5.

[Read 14th December, 1874.]

THE subject of retro-peritoneal pouches when taken in connexion with the occurrence in them of intra-abdominal herniæ is a very interesting one, especially as so few of these fossæ exist. Only three such cavities have as yet been described, which are as follow:—

1°. The "Fossa Duodeno-Jejunalis" on the left side of the 3rd lumbar vertebra.—This fossa has been fully described by Huschke,* and has been found the seat of an intra-peritoneal hernia by Treitz,† Chiene,‡ Peacock,§ and Gruber.‖

2°. The "Recessus Ileo Cœcalis" (fig 1).—This concavity is very constant and is frequently a deeply-excavated hollow. It may be from 0·25 of an inch to 1·25 inches in depth, and may be seen lying between the mesenteriolum of the vermiform appendix, the plica, ileo-cœcalis, and the cœcum. This fossa has been described by Professor Luschka of Tubingen¶; it may (not unfrequently) contain a cyst.** Hernia has been found herein by Engel.††

3°. The "Subcœcal Fossa" figured in the sketch (fig. 2) has been described by Luschka.‡‡ No example of hernia has as yet been described as occurring in this fossa, as its mouth is always very wide in proportion to its depth. It only exists when the mesocœcum is imperfect.

Through the kindness of Dr. Macalister, who pointed it out to me, I now bring forward another as yet undescribed form of these retro-peritoneal fossæ which came under my observation on the 16th of November last in the Trinity College Dissecting Room.

On opening into the abdominal cavity of a man of about 55 years of age, in the right iliac fossa, an abnormal fold of iliac fascia was discovered bounding a sac or pouch of moderate size. It consisted of a thin, strong semi-transparent arch extending outwards from the border of the psoas magnus muscle to the crest of the Ilium, part of the

* Lehre von den Eingeweiden des Menschlischen Körpers. Leipzig, 1844, p. 216.

† Hernia retro-peritonealis. Ein Beitrag zur Geschichte innerer Hernier Prag, 1857.

‡ Journal of Anatomy and Physiology, 2nd Series, No. 2, 1868, p. 218.

§ Trans: Pathological Society of London, Vol. 2., page 60.

‖ St. Petersburges Med. Zeitschrift, 1831, Bd. 1.

¶ Ueber die peritonæale umhüllung des Blinddarmes und über die fossa ileo-cœcalis. Virchow's Archiv, Vol. 21, 1861. s. 285. This sac is really a portion of the visceral, and not of the parietal peritoneum.

** Schott, Wiener Wochenblatt, No. 44, 1862.

†† Wiener Med. Wochenschrift, 1861, No. 10.

‡‡ Die Anatomie des Menschlischen Bauches, s. 154.

fascia covering the muscle; the mouth of the sac or fossa thus formed looked upwards towards the cœcum.

The peritoneum lay on the fascia, to which it was only loosely connected, and was easily separable from it, but part of it was involuted and tucked into the fundus of the sac. The subserous tissue was lax and could be separated without difficulty.

The measurements of the fascial fold were as follow:—

Its crescentic free border arose from the fascia over the psoas at a part 3½ inches above Poupart's Ligament.

The measurement across from the border of the psoas magnus to the crest of the ilium was 2·7 inches.

Its attachment extended 3½ inches behind the anterior superior spine of the ilium.

The sac itself was ·7 of an inch in depth.

The fascia was quite free from the tendon of the psoas parvus, which was inserted as usual. A branch of the anterior crural nerve lay on the margin of the fascial fold forming its superficial edge.

The cœcum had not descended nearly as far as usual, but lay loose in the right lumbar region, attached by a mesocœcum four inches broad, and which was continuous with the mesentery. The vermiform appendix lay within this mesocœcum, posterior and inferior to the cœcum, and with no trace of a mesenteriolum; it was moderately long and bent on itself at the lower end. There was no nerve on the free edge of the smaller left "Fossa retro-sigmoidalis." There was a cicatrix-like mark on the left side below the peculiar fold, but no sign of inflammation.

This sac which we are considering may be called the "Retro-cœcal Recessus;" it might easily become the seat of an hernia, and, therefore, is of some importance. It differs from the sac described by Luschka in that the opening of the fossa described by him looked downwards, whereas that before us looked upwards.

This abnormality is remarkable from the fact of its not having been described before. It may, therefore, fairly be considered unique.

XIV.—LABORATORY NOTES.* By CHARLES R. C. TICHBORNE, Ph. D., F. C. S., &c.

[Read December 14, 1874.]

3.—*On the Solution of Alloys and Metals by Acids.*

HAVING to form a number of estimations of tin, in alloys of tin and lead, I found it necessary to effect solution of the mixed metals in Hydrochloric Acid, and to devise a quick and expeditious method of bringing this about without loss of substance. The alloys were dissolved in the ordinary manner and according to the usages of laboratory experience, that is to say—in each case a weighed quantity of the alloy was coarsely rasped by a clean plumber's file, and placed into a rather capacious flask, with the necessary quantity of pure Hydrochloric Acid; an Indian-rubber stopper was inserted, through which passed a short tube. The flask was placed upon a sand bath at an angle of about 45 degrees, so that no loss from spitting could take place up the neck. Platinum was introduced for the purpose of making an energetic voltaic circuit and to assist the solution. The action with the alloy itself is energetic enough at first, but it gradually subsides and becomes languid after the Hydrochloric Acid has become in any degree saturated. If the platinum, however, be introduced, this sluggishness is avoided. From the nature of the experiment time was an object of considerable importance, and yet a great excess of acid was not desirable. The introduction of platinum foil to facilitate solution of other metals is no novelty, but I found it convenient to use a modification, which I consider sufficiently important to note.

From the electrical condition of the platinum foil and its great attraction for the electro-positive hydrogenium, an intermittent and rather curious reaction is set up in the flask where solution is effected. The platinum foil sinks on its introduction until it touches the particles of metal lying upon the bottom of the flask, when it instantly becomes covered with the electro positive hydrogenium, and the foil rises to the surface of the liquid, and there discharges the hydrogen gas, and then sinks again until it comes in contact with the alloy, when the phenomenon is repeated, as long as any alloy remains. It is therefore self-evident that this intermittent process must greatly retard the consummation of perfect solution.

To remedy this, I substitute small spheres of platinum about the size of swan shot. The rounded particles of platinum act perfectly, the hydrogen being much more readily illiminated from the spherical surface, and in no case does the platinum float. If the operation is performed in a flask as recommended, from the shape of the vessel these particles of platinum are also in actual contact with the alloy during the whole of the process.

Solution is effected in nearly half the time, and the loss upon the

* Continued from Ser. II. Vol. I. Science, p. 105.

platinum shot (probably from attrition) was found to be only 0·0001 per cent. during the solution of four grammes of alloy. I may mention that the platinum shot referred to can be procured at any of the metallurgists who produce the fused platinum in this form.

4.—*On Fluorescence as a Means of detecting Adulteration.*

The following note will be interesting as illustrating how the fluorescence of any substance may be used for its detection in the presence of a non-fluorescent substance:—

About seven years ago, I made use of this phenomenon for the detection of turmeric when present in mustard in a report upon the commercial aspect of that substance.*

Lately it has been referred to by one of the public analysts in England, as a method by which turmeric may be detected, and as it is so extremely delicate in its results, and yet so easy of application, I have thought it desirable to draw attention to the general principles upon which this phenomenon of fluorescence may be used for such purposes, and also with the view of laying claim to the idea.

If the adulterant is fluorescent, and the substance into which it is introduced is non-fluorescent, we have at once a ready means of examining any number of samples with much more delicacy than the usual chemical reactions will give. Thus, let us take the one to which we have already referred, the mustard of commerce.

The seeds of the black or white mustard yield a yellow, colouring matter soluble in spirit of wine which is devoid of fluorescence. Turmeric is always present in the inferior qualities of this condiment because the actual adulterant is wheaten flour or rice, the turmeric being necessary to bring the white adulterant up to the same shade as the ground mustard seeds, therefore the samples vary from 0·5 per cent. to 0·05 per cent. of turmeric. Now, with such minute quantities of turmeric the alkaline test is very unsatisfactory—in fact, all chemical reactions are unsatisfactory when dealing with such a minimum of adulteration,

But the great elegance of this fluorescent test consists in the fact that within reasonable limits, *the more dilute the solution the more strongly* does the fluorescence test come out. The non-fluorescence of the colouring matter of all substances that are adulterated with a fluorescent substance should, in the first instance, be exactly and scientifically determined. This is easily done by any one who has the necessary arrangements. In the case of the mustard yellow, Mr. H. Draper kindly examined it for me, by the light of the spark formed between two steel wires (such a spark being the best for the purpose).

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* *Medical Press and Circular.*—Report on the Adulteration of Mustard. Vol. 8. New Series.

The steel points were placed in connexion with a four-inch intensity coil and a small leyden jar was interposed in the circuit. The battery used consisted of three Groves elements. In examining by this method, ordinary glass vessels must be discarded, because even the strongly marked fluorescence of turmeric is more or less masked by the blue fluorescence of the glass.

In a quartz cell (two plates of quartz in a frame of gutta percha), these observations can be carried on with the greatest accuracy. Mr. Draper's observations prove that, whilst the colouring matter of the true seeds gave no fluorescence, the presence of so small a quantity of turmeric as ·005 per cent. could be readily detected.

Before we are justified, however, in using this phenomenon as the test for the presence of any substance, it is necessary to put it to a crucial examination, such as that detailed above to find out how far the particular substance under examination is capable of giving fluorescence. But it is not at all necessary that we should submit it to the light of a spark in the practical application of the test. The fluorescence of an ordinary white glass flask is not observable under the ordinary diffused light of a laboratory, but the ordinary fluorescent substances (so called), are easily recognized under such conditions. It is only necessary therefore to form a tincture of the substance to be examined. The observation of Mr. Horner* who finds that fluorescence is wonderfully developed by castor oil, may be made use of with great advantage. A drop of castor oil that has been passed through adulterated mustard, upon a filter, appears green when dropped upon a black plate in ordinary daylight. If the mustard is pure, no coloration will be perceived. I have met with some specimens of "Saffron," (the stigma and style of *Crocus sativus*), which give a fluorescence. They were evidently adulterated because the flowers of saffron give no fluorescence. This saffron is a most expensive drug, and is therefore very liable to adulteration.

5.—*On the Printing Inks of the Sixteenth and Seventeenth Centuries.*

The Printing Inks of the present century differ somewhat from those of the sixteenth and seventeenth centuries, and as this difference may affect the preservation of valuable works of art, I have thought it desirable to embody my observations upon this subject in a short note.

The present ink used in printing books and valuable works of art, essentially consists of Carbon in a fine state of division, ground up with a mixture of oils, soaps, and a substance called printer's varnish.

This last named substance may be viewed as the important vehicle by which the Carbon, or pigments, is bound to the surface of the

* Philosophical Magazine, September, 1874.

paper. The printer's varnish is in all good printing ink linseed oil, more or less oxidized—but the oxidation may vary in degree from its first stages, known as ordinary drying oil, and made by the action of acetate of lead upon linseed oil, or it may be burnt until it becomes a stringy varnish that can be drawn into threads.

The first is a fluid linseed oil hardly changed in its properties, whilst the last is a tough resinous mass scarcely soluble in oils, and quite altered in character from the original compound. This last may be considered as a glyceride of lineolic acid.

I have found that the older printing inks are more easily saponified and washed off by alkalies, than those of the last century, and that in this respect there is a marked difference. In their general character they agree, as carbon seems to have been the basis of printing ink from the time of Johann Faust, and from this reason printed matter will bear the action of acid oxidizers, or bleachers, with impunity; but many, if not all, the printing inks of the fifteenth and sixteenth centuries are more or less sensitive to the action of alkalies. Some specimens are so extremely sensitive to this alkaline influence that on introducing them into a weak solution of ammonia, the characters instantly float off the surface of the paper, although they may have previously withstood the action of a powerful acid bleaching bath. The only explanation that I can offer is that the oil or oils used as vehicles were not formerly submitted to the boiling process, which in the more modern inks has thoroughly resinified them.

It is also probable that copaiba or other balsams were freely used in the more ancient inks. These balsams are easily acted upon by diluted alkalies.

It will be seen by the following details that this peculiarity was not confined to one country.

Ink insoluble, or nearly insoluble in alkalies.

Various pamphlets published in England and Ireland, 1720 to 1730.

Modern English Inks, all the specimens tried.

Modern Leipzig Ink.

Ink soluble in diluted ammonia.

"Agricola. De re metallica," Basileæ, 1561.

Some of Albert Durer's plates.

"Libri Solomonis," Paris, 1542.

"Titi Livii Historiarum Libri," Amsterdam, 1635.

"Le Martyrologe Romaine," Lyons, 1636.

"Portraiture of his Sacred maiestie," London, 1648.

1876, Feb. 26.

XV.—ON APOTHECIA OCCURRING IN SOME SCYTONEMATOUS AND SIROSIPHONACEOUS ALGÆ, IN ADDITION TO THOSE PREVIOUSLY KNOWN. By WILLIAM ARCHER, M. R. I. A. (With Plate 6.)

[Read December 14, 1874.]

It is now some years since, upon examining some examples of the by no means uncommon plant, long (and by some still) accepted as algal, *Stigonema atrovirens*, Ag., that I was attracted by the peculiar enlargements of the branches, and was much interested in perceiving that this plant showed, imbedded in these swellings, distinctly lichenous fructification—apothecia, as well as the so-called spermogonia. Upon searching out the literature of the subject, I found from Bornet's valuable paper* that my discovery had been previously well known, and that my specimens fully bore out the description he gave, with the exception of the hyphæ subsequently discovered by Schwendener. Bornet, indeed, argued from the fructification which he had proved to belong to this form, that it should no longer be accounted an alga, but relegated to the lichens as *Ephebe pubescens*.

But it occurred to me that Bornet's supposition, at the period of his writing the memoir on Ephebe, that other forms of apparent affinity (*Stigonema mamillosum, St. mammiferum* and others) were of another and different nature—that is, "algæ," whilst *E. pubescens* was a "lichen,"—could not be borne out.† It struck me, indeed, that if *Stigonema atrovirens* were no alga, but a veritable lichen, that then the other *Sirosiphonaceæ* and *Scytonemaceæ*, if likewise patiently examined, *must* prove themselves of the same nature. *Stigonema mamillosum* and Sirosiphon- and Scytonema-forms, I thought, could hardly be less lichens than *Ephebe pubescens* itself; nor was I then aware that such in some cases had, since Bornet's paper referred to, been actually accepted as a fact.

Having at that time more frequent opportunity of finding, amongst the Wicklow hills, the commoner representatives of the class than more recently, I then made a considerable number of gatherings and examined them as closely as I could for "apothecia." I found it a more tedious labour than might be supposed, for, though I by and by found apothecia in three genera, I had to make very many hundred gatherings and examinations in order to be successful in encountering even a few "fertile" specimens; for, though possibly more frequently "fruiting" than one might suppose from that fact, the opacity and

* Bornet, "Recherches sur la Structure de l'*Ephebe pubescens*," in "Ann. des Sci. Naturelles," 3 ser., tom. xviii., p. 155.
† Bornet, loc. cit., p. 167.

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closely tufted habit of most of these forms contribute to rendering the little dark lateral tubercles usually formed by the apothecia somewhat readily overlooked, whilst they might in some forms be even passed over under a low power (the only useful way of *searching*) as merely rudimentary "branches."

It is matter of regret to me now that I did not at the time bring forward some notes upon these forms before the preparations I had made had become spoiled; and it is also a matter of still greater regret that I did not secure some drawings more in detail than the rough sketches I am able to offer. But as even a chalk drawing on a black board is better than none, so the accompanying figures (Pl. 6) may serve a temporary purpose until better are forthcoming from some source, whilst the figures of the spores themselves may be accepted as accurate.

I at once assumed from our knowledge of *Ephebe pubescens*, coupled with the additional fact of having found *apothecia* in *Scytonema*, *Sirosiphon*, *Stigonema* (*mamillosum*), that these genera and probably the whole of the *Scytonemaceæ* and *Sirosiphonaceæ*, could be no longer properly accounted algæ, but should be relegated with *Ephebe* to the lichens.

But another and a different solution is put forward now-a-days by Professors de Bary and Schwendener, and those (Reess, Bornet, Treub, and others) who accept the new doctrine of the nature of lichens. It has, as is well known, been previously long supposed that, assuming the gonidia to be really organs of the lichens, these may here and there (and by no means unfrequently) become detached from the parent plant, and, under conditions unfavourable to their forming a new lichen, carry on an independent (probably abnormal) alga-like existence; and hence that many of the so-called unicellular and some of the filamentous algal growths, which may have been regarded as specifically distinct organisms, should really be expunged the list of independent plants. On the other hand, Schwendener and the new school hold that the "lichen-gonidia" *are* veritable unicellular, or, as the case may be, according to the type of lichen, filamentous algæ which vegetate within the lichen-thallus as the serviceable (assimilating) host plants of a parasitic ascomycetous fungus, the "lichen-hypha." A *resumé* of the whole question, of the views put forward and the arguments adduced, so far as the discussion has reached, both for and against, I have recently endeavoured to bring together,* and it is hence superfluous to attempt here to recapitulate the particulars and points of his hypothesis, except as they bear upon the group immediately in question.

In his able and interesting work on the "Gonidia-forming Algal-types,"† and beginning with the "Phycochromaceous" series (*Nostochinæ*, Näg.), Schwendener places the *Sirosiphonaceæ* in the front rank.

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* "Quart. Journal Mic. Science," vol. xiii., N. S., p. 217; also vol. xiv., p. 115, in which places the references to the various authors are given.

† Schwendener: "Die Algentypen der Flechtengonidien," Basel, 1869.

He justly observes they should begin the series, amongst the bluish-green filamentous forms, by reason of the well-expressed contradistinction offered by them between apex and base, also by reason of their being marked by a formation of true branches, as well as, in their higher representatives, showing an evident accession to their thickness by subsequent growth. Possessing these specialities, they at the same time, however, show an unmistakable affinity on the one hand to the *Scytonemeæ* and *Rivularieæ* in the common possession of "heterocysts" and an apical growth, and on the other to the *Nostochaceæ*, which, wanting apical growth, form a transition to the *Oscillarieæ*.

Prior to the propounding of the new hypothesis, however, certain of these forms, which, if met with without apothecia, would have been referred to the genus *Scytonema*, had been found with apothecia and thereupon new genera were formed for them by Itzigsohn and Nylander under the names *Ephebella*, Itzigsohn, and *Gonionema*, Nyl. (or *Thermutis*, Fr. ?). In fact, they seem to have regarded the "barren" and the "fertile" plant as each belonging to distinct genera, even as appertaining to different classes—that is, that the "barren" was to be accounted an "alga" and the "fertile" a "lichen."

Of course, had Schwendener's view, but comparatively lately put forward, been *then* current, and had it been adopted by the discoverers of those apothecia-bearing *Sirosiphonaceæ* and *Scytonemaceæ*, the case would have been different: the *new name* would in that case have been, as I take it, understood to be applied to the "new ascomycetous parasite," within the *Sirosiphon*, or the *Scytonema*—the double names should still pass current, for, in that case, they would stand for essentially distinct things, and no less so because these occur *sometimes* living in consort and in a state of mutual physiological dependence.

The present communication, therefore, loses much of the significance it might have been at least temporarily held to possess, from not being brought out at the time the observations were made, but *after* the new theory had been not only propounded, but had gained a large amount of currency.

Nevertheless, although more superficially put forward than if I had made the matter public at the time of the observations, and when these were fresh in my mind, this will, I think, be the first record of "apothecia" being noticed in at least five fresh forms or species referrible to separate "genera" (*Scytonema*, *Sirosiphon*, *Stigonema*) in the algal point of view. If this record had been brought out at that time, indeed, it would have pointed, as I should have taken it, to the assumption that these, in place of genera of algæ, were in truth genera of lichens—not "new" lichens, but lichens not taken previously "in fruit."

With respect to *Ephebe* and *Spilonema*, Schwendener argues, that a genetic connexion between the hyphæ and the gonidia is impossible. For the whole chain of gonidia leads onwards to the apical cell, by the unlimited subdivision of which new cells continuously originate, which are themselves again to be regarded as mother-cells (in those genera) of so many groups of gonidia. The assumption of a new formation of gonidia by growing-off from the hypha has no justification whatever;

those who hold such a view must take refuge in the assumption of the formation of the first gonidium in the germination of the spore—a process which has not yet been observed in any lichen, and, *à priori*, never will be.

But it must be pointed out that, according to Schwendener and others, Scytonematous and Sirosiphonaceous algæ are claimed as forming "gonidia" under two distinct circumstances or conditions: they are, according to their researches, to be found in certain lichens, *either* as mere accidentally detached portions of filaments wholly surrounded and involved by the hyphæ, and caught up bodily in the substance of the lichen-thallus in a completely disorderly manner, *or* they exist as perfect plants of their type as algæ, the alga-thallus quite unaltered in outward configuration, but permeated along the length of the filaments by the hyphæ, which run between the rows of green cells. When the algæ, as is assumed, are in the former way compelled to become the "gonidia-formers," it is the hyphæ (not the algæ) which must be held to control the configuration of the thallus and determine the characteristic build-up of the "lichen;" when the algæ serve in the latter way as gonidia to the intruding hyphæ, the former (not the hyphæ) retain their proper "specific" exterior, the build-up of the (algal) thallus is not externally altered, and it is only a microscopical examination which would reveal anything unusual or offer any "lichenous" indication. It is as regards this latter gonidial condition that Schwendener's arguments, as to the impossibility of the genetic relationship of the hyphæ and the young apical gonidia, by reason of the latter being formed prior to the *arrival* at the apex of the hyphal filaments, are directed, and to this condition it is that the notes here brought forward apply.

One of the most common of the *Scytonemaceæ* is the *Scytonema myochrous*, forming silky cushion-like tufts on wet rocks, when dry, of mouse colour, when wet, more of an olive hue; it seems to love best a pretty constant trickle, and if the force of the little current be somewhat strong, the mass may form a rather long drawn-out pad, stretching down the inclination of the surface over which the little flow descends. Very often in my searchings I gathered little portions from various sites, sometimes very wet, sometimes, indeed, dried up by drought, and once only was I so fortunate as to find examples showing apothecia. I regret I have mislaid my rough drawing of the apothecium itself, but fig. 1 is a sketch of the spores within an ascus. The general appearance of the apothecium, however, is like that of *Sirosiphon*. The asci were accompanied by linear paraphyses; the spores were four in an ascus, nearly colourless, broadly elliptic, simple, with two bright corpuscles, each with a minute dot in its centre immersed therein, one towards either end. Length of the spore, $\frac{1}{3500}''$, breadth, $\frac{1}{5250}''$ (figs. 1, 2).

Another *Scytonema*, whose precise identity seems difficult to determine, also presented apothecia. This too I found on only one occasion; the contents usually formed a thin, somewhat irregular, central string up the middle of a somewhat thick striated sheath, except near the apices of the "branches" (which sometimes were given off singly) in which they were thicker and quadratic (figs. 3–6). In this *Scytonema* the nearly mature apothecia were globose, smooth, shining, of a dark brownish-chocolate colour, usually placed somewhere along the length of the filament, but might be occasionally terminal (figs. 3–6). Sometimes they seemed almost to form an interruption of the continuity of the filament, or as if inserted into a special rounded excavation in it, and separated from it by a sharp line of demarcation (fig. 4). Certain of the filaments showed here and there what seemed to be agglomerations of brownish-coloured granules, which by their quantity caused a distension of the filament and an interruption of the string of contents; these I took to be incipient apothecia, judging from their position; but this is of course not certain (figs. 9–11). The more mature apothecia seemed somewhat depressed at the top where the opening occurs (fig. 6). Like the apothecia of all these forms the present were very tough and intractable, the only plan to obtain the asci separate with their spores, on account of their minuteness, being to cause them to become ejected by (very forcible) pressure. In the present instance this was of more than usual difficulty, and I was unable to press out an ascus intact to discover if it was 4- or 8-spored; I believe, however, the latter. The paraphyses were slender, linear. The separated spores themselves were somewhat readily obtained, and they are different from the preceding, being much longer and narrower, of lanceolate outline, simple, colourless, with a minute dot-like corpuscle towards either end; length of spore, $\frac{1}{1615}''$, breadth, $\frac{1}{7000}''$ (fig. 8).

Coming to *Sirosiphonaceæ*, another case is offered by *S. alpinus*. Here the apothecia were smooth but not shiny, blackish, globular, variously situated, sometimes in the axil of a branch (fig. 13), sometimes along the length of the filament (fig. 12), or even terminal. Here, as elsewhere, it was only by pressure that the asci and spores could be ejected. The asci, as elsewhere, at first filled with a grumous granular substance (figs. 16, 17), were, when mature, 8-spored (fig. 18). Sometimes I saw asci with the contents contracted to a broadly fusiform figure, and then divided transversely, thus producing two conical bodies as if base to base (fig. 15). The paraphyses seemed to be of two lengths, the shorter about half the length of the asci, linear, pointed, the longer about one-half longer than the asci, nearly twice broader than the former, with truncate end (fig. 17). The spores here were different from either of the preceding, being uniseptate, oblong, somewhat constricted at the middle opposite the septum, each end broadly rounded, colourless, each cavity showing a single central bright minute corpuscle; length, $\frac{1}{16150}''$, breadth, $\frac{1}{8110}''$ (fig. 14).

Another Sirosiphonaceous form, *S. pulvinatus* or *S. Heufleri*, showed apothecia. They appeared in a young condition to be hemispherical, when mature, globose, sometimes as if somewhat produced upwards, and truncate at the opening (fig. 20). Unlike the previous, they did not appear smooth when young, but as if slightly hirsute externally (fig. 19). The clavate asci sometimes appeared somewhat truncate (fig. 21); paraphyses very inconspicuous—indeed I am more inclined to think there were none; the asci were densely crowded. Many examples showed asci filled with granular contents, the spores not yet formed. The asci when mature were 8-spored (fig. 22), the spores resembling in size and figure (but were very slightly longer than) those of the second form of *Scytonema* referred to, but they differed in not having the two bright corpuscles immersed therein, and in showing a pale green colour. They were long and narrow-lanceolate, greenish; length, $\frac{1}{1560}''$, breadth, $\frac{1}{7000}''$ (fig. 23).

The last form which rewarded my search in showing apothecia was the form recorded in "Flora Hibernica" as *Stigonema mamillosum*, but the distinction which may exist between the plant in question and *Stigonema mammiferum*, Thwaites, or *Sirosiphon coralloides*, Kütz., are not very apparent. Our plant grows in running water, attached to stones at the bottom of mountain streams. It is much more rare, seemingly, than any of the previous species, and is a very pretty plant under a moderate power of the microscope, especially a young and flourishing one, studded by the curious short and blunt branches, giving the "mamillate" appearance, with the phycochromaceous contents bright in colour. The apothecia resembled those in the *Sirosiphon* above alluded to; they were blackish, globose (fig. 24); paraphyses linear, somewhat longer than the asci (fig. 25); spores four in an ascus, greenish, uniseptate, oblong, the septum appearing like a pale and hyaline slender transverse band, and somewhat constricted at the middle opposite the septum: thus the halves ovate, somewhat tapering to the bluntly-rounded ends, each cavity showing a bright corpuscle immersed in it; length, $\frac{1}{2336}''$, breadth $\frac{1}{4660}''$ (fig. 26).

In all these forms I searched as well as I could for so-called spermogonia, but was unable to detect any. These are comparatively so readily perceived in *Ephebe* (I myself found them before I was aware of Bornet's published account of them, or of the apothecia in that plant) that my non-success was the more disappointing.

Nor, after many trials by boiling in caustic potash, was I able to satisfy myself of the presence of hyphæ, as can be so readily done in *Ephebe*, as first pointed out by Schwendener; there can, however, be little reasonable doubt but that they must exist, though the seeming nascent apothecia in the second form of *Scytonema* referred to gave no indication of their presence; but that in itself would prove nothing, as the hypha cannot be seen in *Ephebe* without boiling in potash. Most probably my experiments were not conducted sufficiently long or carefully, for Bornet has shown the existence of the hyphæ in his *Spilonema paradoxum*,* and in his *Lichenosphæria Lenormandi*.†

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* Dr. E. Bornet: "Description de Trois Lichens Nouveaux," in "Memoires de la Soc. Imp. de Cherbourg," vol. iv., p. 225, t. i., ii.

† Dr. E. Bornet: "Recherches sur les Gonidies des Lichens," in "Ann. des Sci. Naturelles," 5 sér., tome xvii., (of reprint, p. 57).

But does it not appear somewhat inconsistent when Bornet, in describing his *Lichenosphæria Lenormandi*, makes use of the following language in the generic character:—"Thallus tenellus, ramosus, fruticulosus, fere omnino *stigonematoideus*, basi corticatus;" and as descriptive of the specific characters—"Thallus fusco-niger, tomentoso-intricatus (altitudo vix 2 millim.), ramulis divaricatis subsecundis"? For, in fact, these words simply describe the thallus of *Sirosiphon divaricatus*, Kütz., which alga forms the host-plant for the peculiar lichenal parasite in question. But when he goes on to describe the apothecia, the thecæ, the spermogonia, the spores, he is giving the characters of the latter, which is the real "new species." In accordance with the new theory, besides the hyphæ, this has no thallus of its own; the hyphæ merely push into the thallus of the *Sirosiphon*, scarcely distorting it or causing any outward alteration, beyond the occasionally exserted apothecia. If it were possible—and there is seemingly no great reason to the contrary—that the spores of this self-same *Lichenosphæria Lenormandi* should afterwards grow upon and into another species of *Sirosiphon*, or, say even into a *Scytonema*, then *some* of the "specific characters" as given, nay, even probably some of the "generic," would disappear and others take their place. It is to be granted, indeed, that on the new theory, when a *Nostoc* becomes invaded by the parasite which converts it into a *Collema*, a very considerable alteration is produced on even the outward aspect of the *Nostoc;* instead of a rounded, lobed, "blobby," and soft lump, it becomes more or less foliaceous, less watery, and more subdivided; but it is the *alga* all the time which submits to this alteration: the true *lichen* is *inside*, only evincing itself externally by its apothecia and by its action on the alga (like a *gall* causing even greater modifications on a higher plant), inciting those changes of external aspect, whilst it is at the same time making use of the assimilating power of the alga to do for it what it cannot do by itself.

There can be little doubt but that amongst these Scytonematous and Sirosiphonaceous algæ quite distinct forms occur; but, on the other hand, there can be almost as little doubt but that Kützing has vastly over-enumerated them—that many of his so-called species are not distinguishable. Now, it is hard to conceive that one and the same parasite would care very much *which* of forms so closely resembling it invaded in order to pursue its course of life. *Sirosiphon divaricatus* seems not to differ much from *S. alpinus;* it is more fruticulose, the cells in the central stems seem to occur in more than double series: what very perceptible barrier is there to the supposition that the parasite, which invades the former to form *Lichenosphæria Lenormandi*, Bornet, might not at another time invade the latter? Would it not then fructify in the same way, show spores alike, &c.? But the parasite which does really invade the latter is not the *same*, as the figure herewith will show, not to speak of the paraphyses, so prominent a feature in the latter, being absent in Bornet's plant. Are these Scytonemicolous and Sirosiphonicolous parasites, then, so *extremely* particular in their choice?

See again the two Scytonemata, resembling in themselves so much and yet with "parasites" so distinct; the spores could not be confounded for a moment (see figs. 1, 2, and fig. 8). Again, see the great resemblance (but certainly not identity) between the spores in the second *Scytonema* and in *Sirosiphon pulvinatus*, algæ mutually sufficiently unlike (see Figs 8 and 23).

It might again be asked whilst the new theory is, as it were, on its trial, at what period of the life of the Scytonema or Sirosiphon does it become invaded by the parasite? At what part of the thallus does it make its entry? It must be near the base, or at least not very high up, for the hypha is found growing pretty nearly *pari passu* with the growth of a branch of the alga, and in the same general direction. But what is to prevent the hypha growing in the opposite direction? Might it not sometimes enter near the apex and grow backwards? Might we not expect sometimes to find hyphæ sticking out from broken-up or distorted examples of these algæ, and then revealing themselves (without the whole mass being boiled in potash) whilst on their way to invade other examples of quite the *same* alga? Or must the hypha appertaining to a particular plant have had its commencement from a spore which found its way to and alighted *somewhere* externally upon the particular *Scytonema* or *Sirosiphon?*

The account given by Itzigsohn of *Ephebella* * is incomplete; he met with apothecia in his species of "*Scytonema*," containing asci, but they had not as yet developed spores. The plant he had in view may certainly be said to be quite distinct from *Scytonema myochrous*. It is probable the fructification would also have been seen, if fully mature, to have been also specifically different. So also are my two forms, both in thallus and fructification. These, proceeding on the new theory, would, perhaps, be relegated as "new lichens" to *Ephebella*, Itzigsohn, or to *Gonionema*, Nylander; but *neither* is identical with *Gonionema velutinum*, Nyl. (of which I have seen examples in the late Admiral Jones's Herbarium), either as regards thallus or spores. The three other forms would probably be referred as "new species" to the "lichenous" genus *Spilonema*, or that referred to *Sirosiphon pulvinatus*, wanting paraphyses, might possibly be relegated to *Lichenosphæria*.

An experimental decision of the "gonidia-question," so far as it relates to these Scytonematous and Sirosiphonaceous forms, is surrounded by not a few practical difficulties. A sowing of spores upon the algæ (as Reess did with *Nostoc*) in a natural condition could only be carried out by an observer residing in or close to the subalpine situations where these plants flourish, as they could not be "cultivated" elsewhere. In order to obtain the spores he would further have, very probably, a troublesome preliminary search, and, on the other hand, there would hardly be a certainty of the plants selected for *inoculation* being themselves previously destitute of hyphæ or apothecia. Of course small portions from various places in a tuft of any given *alga* could be

* Itzigsohn, in "Hedwigia," 1857, p. 123.

previously well examined, which, though if indeed found to represent the alga "pure and simple," would not render it absolutely conclusive that some *other* portion of the tuft might not already have been invaded by the "parasite." However, having selected some plants for experiment, they should be well inoculated with spores and portions removed from time to time for examination and experiment. If found satisfactory, it would be interesting to try to "cross" spores from the *same* and from *different* species (as, for instance, such as fig. 5 and fig. 26, or fig. 2 and fig. 19), in order to see the result, and whether the apparent fixity of the forms and the apparently extreme exclusiveness of the "parasites" be true or not, or ultimately whether the theory be true itself or not. Whether, for the time being, the truth of the new theory be previously assumed, or its untenability be presupposed, would matter very little, if the suitable opportunity and ready field of operations were at command of the observer. It would seem as if in this way only can either presupposition be justified or negatived.

Pending the ultimate decision at which the great lichenists who are at work on the broad question may arrive as to the true nature of these interesting plants, and pending, too, the discovery of the spermogonia of the forms here referred to, as assisting to throw a light on their mutual affinities and relative position, I may well leave to more skilled hands the desultory notes brought forward in this communication, touching their general bearing and ultimate application as regards one of the most interesting and problematic botanical questions of the day.

XVI.—Microscopical Structure of Rocks. Report No. I.—Ingenite Rocks. By G. H. Kinahan, M. R. I. A., &c. (With Plates 7 and 8).

[Read June 8, 1874.]

In these reports on the microscopical structure of the Ingenite Rocks it is proposed to describe each rock under the names adopted by me in "A Handy book of Rock Names,"* while all the minerals will be called by Dana's names. With each specimen, prior to entering into its microscopic structure, will be given a description of the rock, as it appears when examined in the field, with the naked eye or with a pocket lens. In this report the felspars will be principally treated of—the power used, except when specially mentioned, being 42.

In a paper read November 13th, 1871, before the Academy, "On the Granitic and other Ingenite Rocks of Yar or West Connaught,"† I pointed out that the granitic rocks seem capable of being divided into *Intrusive granite* (Highly siliceous granite), *Granite for the most part non-intrusive* (Basic or oligoclase granite), and *Elvanyte* (Quartz-porphyry;‡ the latter rocks being the passage-rocks between the typical granites and the plutonic rocks. It was also shown that between the typical Highly siliceous granites and the Basic granites, there are granites partaking of the nature of the former in being intrusive and of the latter in containing as essential constituents, such minerals as oligoclase, amphibole, and the like. Moreover, it was shown that typical Basic granite seems to be always more or less of metamorphic origin, and that it graduates into the Intrusive oligoclase granite, while the typical Highly siliceous granite is intruded in independent masses. Suggestions were also given as to the probable formation of the granites, but to enter into that subject now, would be foreign to the purpose of this report; we will, therefore, refer those interested, to that paper and to the Handy book of Rock Names, pp. 37 to 39.

The first rocks to which we shall draw attention, belong to the second group of granitic rocks or *Granite for the most part non-intrusive* (Basic or oligoclase granite), the specimens having been collected in the Co. Galway.

B.[1] *Porphyritic granite from Knockanavoddy* (Galway sheet 93).—This rock, examined in the field, seems to contain flesh-coloured, greenish, and dull white felspars, glassy quartz, dark coloured amphibole, black mica, and pyrite. There are also small spangles of white

* Published by Robert Hardwicke, London.

† *Vide* next paper and also *Handy book of Rock Names.*

‡ A fourth group, *Protogene*, is also given provisionally in the Handy book. Protogene I now believe ought to be included among the sub-groups of the Basic granite.

mica and widely disseminated crystals of titanite. The dull white is the most abundant felspar in the rock, but the flesh-coloured appears in large crystals, often twins, and gives the porphyritic character to the rock mass. Most of the black mica, the amphibole, and the pyrite, occur associated together in nests, the quartz forming the skeleton of the rock. Of this rock two slices were cut, one containing one of the large flesh-coloured felspar crystals, the other being from a portion of the rock showing its ordinary character. In the latter slide we find the felspars are principally represented by the white variety, only one or two small pieces of the flesh-coloured being present, while the green is scarcely represented, but in the other slide all the minerals mentioned in the field list are represented.

No perfect crystals of any of the felspars appear in the portions of the rock from which the slices were cut, but the flesh-coloured seems to be nearest perfection, and we know that in other portions of the rock mass, perfect crystals of this kind of felspar can be procured. The dull white and the green felspars seem to be jumbled together, the white predominating. In the nests, containing pyrite amphibole and black mica, these minerals seem to have crystallized out in the order in which they are mentioned; indeed, in places, the pyrite and amphibole seem to have crystallized out prior to the felspars, as perfect crystals of both occur in them, but the mica seems to have been formed subsequently, as flakes of both black and white mica are found in places margining the felspars. The mass of the quartz fills the vacancies left after the other minerals were formed, but blebs of quartz occur in the felspars. The titanite when it occurs is always in well formed crystals.

Flesh-coloured felspar.—This according to Haughton is orthoclase. It seems, however, to be very irregularly constituted and to contain many impurities. When we examine a slice of white orthoclase from Ytterby, Sweden, for a specimen of which I am indebted to my colleague, F. Rutley, F. G. S., we find it to consist of nearly parallel transparent and semitransparent lines (see fig. 1, Pl. 7) alternating, which under a higher power (238) shows the lining to be due to systems and lines of minute gas bubbles. This structure is traversed obliquely by lines of fracture, (?) and when examined with the polarizer the matrix of the mineral appears mottled in places with more or less irregular specks and patches; it is sometimes marked with irregular lines, and in some places exhibits a tendency to a structure parallel to the lines of fracture (?). Under the low power (42) few included minerals were observed, the most remarkable being small crystals of pyrite (?) and minute blebs of quartz.

In one of the slices of the Knockanavoddy granite, there is a large twin crystal of flesh-coloured orthoclase, in which the junction of the crystals is most marked. In the left hand crystal at the top there is a wavy oblique lining that does not appear in the rest of the portion under examination, but the most conspicuous structures in both crystals are irregular and irregularly placed lines rudely parallel or nearly so to the junction of the twins, and this structure under a power of 296 is found to be due to systems of minute gas bubbles, while the oblique lining seems to be due to lines of shading caused by transparent and translucent layers.

In this mineral there are numerous inlying minerals or mineral secretions, the most conspicuous being blebs of quartz which usually have translucent nuclei, but a few have similar characters to the blebs of quartz characteristic of the Elvanytes—other minerals observed were amphibole, mica, pyrite, and magnetite. In fig. 3, Pl. 7, is shown a bunch of three crystals of amphibole associated with a flake of mica. In the associated orthoclase was observed a faint lining parallel to the longer axis of the amphibole crystals, but the most conspicuous structure is that of the lines due to the systems of minute bubbles, somewhat similar to those mentioned when describing fig. 2, Pl. 7. In the neighbourhood of the amphibole crystals, are many foreign particles scattered about, some being roundish, but a few having irregular crystalline forms, all have translucent centres but some are surrounded by crystalline rims of quartz. A remarkable crystalline mass observed in the orthoclase is represented in fig. 4, Plate 7. The dull grey portions are slightly iridescent and of similar appearance to the dull white felspar hereafter to be described. In the orthoclase are also subvitreous, opaque black crystals; two of which are represented in fig. 2, Pl. 7.

Under a power of 238 some of the minute opaque specks appear to be magnetite while others are probably pyrite (fig. 5, Pl. 7).

In the smaller crystals and masses of the flesh-coloured orthoclase, the structure appears to be more regular; as we find the crystals crossed by wavy lines (fig. 6, Pl. 7) which under a higher power (238) are found to be due to clouds of minute gas bubbles which lie in irregular, more or less parallel planes. These smaller crystals of the orthoclase seem to contain only a few imbedded minerals principally blebs of quartz and pyrite (?).

Dull white felspar (Adularia?).—This mineral in the Knockanavoddy granite seems generally to occur massive; there are, however, in places well developed crystals, sometimes of considerable size. Under the low power (42) this mineral seems to be irregular in its structure. Some masses are nearly opaque, but in them, irregularly scattered, are numerous iridescent specks, while in some are translucent portions, seemingly of a triclinic felspar, as they transmit ribands of light (fig. 7, Pl. 7). In a crystalline mass (fig. 8, Pl. 7) was detected a lined structure; under polarized light, opaque lines, more or less regular, alternating with subtranslucent iridescent broken lines. With a high power (386) the cause of the lining is very obscure, as the constituents are not found to be in layers. An opaque constituent, however, has a tendency to lie in long irregular patches, parallel to the lining, while the iridescent spots form groups in short lines.

The peculiar appearance of some of the masses of felspar appears to be due to opaque, subtranslucent and translucent particles that are irregularly associated together. In one mass was observed what seems to be small gas bubbles of the same class as those mentioned when describing the flesh-coloured orthoclase, but in no other of the masses could they be detected, and they do not appear to affect the structure of the mineral. Very few inlying minerals were observed in this felspar, the most marked being minute blebs of quartz, and black specks that may be pyrite or magnetite. This felspar is evidently one of the orthoclases, probably adularia.

Greenish waxy felspar (Oligoclase?).—This triclinic felspar is not very well represented in either of the slices that were cut from the specimen of the Knockanavoddy granite, as in one it scarcely appears, while in the other only portions of crystals occur; but in other places in the neighbouring rock we know it was more frequent. This felspar we suppose to be oligoclase, and we will, therefore, first describe the appearance of oligoclase from Ytterby, Sweden (F. Rutley). A slice of the latter mineral under the low power (42) is found to have originally consisted of regular lines of darkish and light colours, which are now broken up by long but irregular spaces, that appear to have been due to shrinkage fissures after the mineral was formed, while scattered about are inlying crystals, blebs, and particles of quartz and small opaque specks (fig. 9, Pl. 7). In fig. 10, Pl. 7, is represented portions of the green waxy felspar of the Knockanavoddy granite. In them the riband of colour is well developed which gives a vivid change of colour when the polarizer is turned, especially if viewed through a plate of selenite; at (*a*) are irregular flakes of mica, at (*b*) a crystal that appears to be titanite, as it is similar to a large crystal, part of which, with two inliers of the same mineral, is represented in fig. 11, while at (*c*) a portion of a roundish but irregular mass of felspar (orthoclase?) appears. When the riband at (*d*) (fig. 10) is magnified (386) the mineral is found to be in places full of minute cavities, some round, others vermicular and sinuose, while the rest have irregular forms. In places these occur in lines parallel to the riband, but the mass of them cross it in clouds and, therefore, can have no connexion with the structure of the rock as seen with the low power (42), but to the clouds crossing the structure, may be due the faint transverse play of colours. The oligoclase from Ytterby, when viewed under the high power (386), is also found to be affected by similar cavities, but in it they have a tendency to run in lines parallel to the riband. These cavities appear to be due to minute gas bubbles attached to the sides of minute vacancies, and these cavities in the Swedish specimens are in general, but not always, nearly parallel to the riband, while in the Knockanavoddy granite they run very irregularly.

B.[1] *Porphyritic granite from Ballynahown* (Galway sheet 93).—This rock, when examined in the field, seemed to consist of flesh-coloured felspar, dull or olive green felspar, quartz, black mica, amphibole, pyrite, and white mica. The flesh-coloured felspar appears principally in large crystals, often twins, which are imbedded in a matrix principally made up of the green felspar and the quartz. Most of the amphibole, black mica, and pyrite are associated together in nests, while the white mica occurs in minute spangles. In places in this rock are isolated crystals of titanite.

Of this rock only one slice was cut, being taken from a portion showing the ordinary appearance of the rock in which the dull green felspar predominated. This mineral was very similar in aspect to the greenish waxy felspar of the Knockanavoddy granite (B.[1]). However, on being placed under the low power of the microscope (42), it was found that the colour and appearance in the field were deceptive, as the mineral now presented characters similar to those found in the dull white felspar of the Knockanavoddy rock (figs. 7 and 8, Pl. 7), while mixed up with it, although not detected in the field, was a triclinic felspar, and associated with them a few small crystals and masses of flesh-coloured orthoclase. Here also as in the Knockanavoddy rock, most of the mica, amphibole, and pyrite occur associated together, while the mass of the quartz forms the skeleton of the rock. No titanite occurs in the slice.

Flesh-coloured felspar (Orthoclase).—None of the large crystals were examined but the small crystals and masses showed exactly similar characters to those found in the small crystals examined in the Knockanavoddy granite (fig. 6, Pl. 7).

Dull green soapy felspar (Adularia ?).—This mineral gives the character described for the dull white felspar of the Knockanavoddy rock, and in it are found portions of crystals and small masses that show the ribands of colour characteristic of the triclinic felspars.

Triclinic felspar.—This occurs in a few isolated masses, and as parts of crystals in or associated with the adularia (?), the structures they displayed being very similar to those already described as characterizing the triclinic felspar of the Knockanavoddy granite.

B.[3] and B.[4] *A slightly foliated porphyritic granite.*—This rock was collected by the late Mr. Jukes, and is marked from Furbogh (Galway). It is similar to the rocks *in situ* on the S. E. and S. W. of Furbogh demesne. In the rock, the most conspicuous constituent is the flesh-coloured felspar, the large crystals of which give the porphyritic character to the rock, but the principal constituents are the dull white and waxy greenish felspars and black mica; irregular leaves of the latter associated with amphibole, giving the foliated structure to the rock. There are also present quartz, white mica, and pyrite, with thinly disseminated crystals of titanite. At Furbogh it was observed in the field that some of the large flesh-coloured crystals had an envelope of dull white felspar.

Of this rock two slices were cut, one containing a portion of one of the large flesh-coloured orthoclase crystals, and the other being from a portion showing the ordinary character of the rock. In both the different felspars are represented.

Flesh-coloured felspar.—The large crystals, as in the Knockanavoddy rock, are generally twins, and in the slice that was cut through one of them, the junction between the twins is a sharp line not an irregular vacancy as was described in connexion with the Knockanavoddy granite. These large crystals, as in the Knockanavoddy rock, contain many inlying minerals, those most conspicuous being quartz and pyrite; while the characters of the small crystals and masses of the flesh-coloured felspar, as in both the rocks previously described (B.[1] and B.[2]), are very regular and similar to those already figured and described (fig. 6, Pl. 7), and contain very few inlying minerals. All these, however, in this and the other granites according to the portion of the crystal exposed to view give remarkable changes of colour.

Dull white felspar (Adularia?).—This felspar when examined is similar in structure to the dull white felspar of the Knockanavoddy granite and the dull green soapy felspar of the Ballynahown rock. In one of these crystals that had a lined structure when viewed with a power of 386, the lining appears to be due to broken and more or less irregular walls of quartz, that give shades of violet when the intervening spaces appear a translucent yellowish white, that had inliers consisting of irregular large white spots, minute black specks, and long black crystals. A group of crystals of felspars in one of the slices (B[4]) under a low power (42) appear to be similarly constituted, but each had a character of its own when viewed with a power of 238 (fig. 12, Pl. 7). The upper crystal on the right hand is of the ordinary character belonging to this dull white felspar, being more or less opaque, and spotted over with iridescent particles. The crystal to the left hand has an irregular lining, somewhat similar to that just now described, consisting of walls of quartz separating whitish spotted portions, except that the quartz walls are thicker and more conspicuous than the intervening portions; while the lower crystal to the right hand is traversed by minute dark parallel lines, that in places in the lower portion of the crystal are associated with partial walls of quartz, all being crossed somewhat obliquely by newer minute parallel whitish lines. In the latter crystal, under a still higher power (386), the dark nearly horizontal lines are found to be principally due to more or less regular lines of probably oblique sections of minute oval tubes (fig. 13, Pl. 8), with which are associated short black lines, that seem to be vacancies, while the slightly oblique lines crossing them appear to have been shrinkage fissures that subsequently were filled by some white substance. All these crystals seem to be the same felspar, with different appearances, due to different structures.

The triclinic felspar (Oligoclase?).—This felspar in these slices is always more or less associated with the dull white felspar, but in the slice with the twin crystal of orthoclase (B[4]), there are some good exposures of crystals and irregular masses, which change from faint ribands of shades of grey and yellowish grey, to shades of violet, purple, and blue. Fig. 14, Pl. 8, represents a portion of one of these crystals under a power of 238. These crystals contain little black inliers (pyrite?) while scattered through the oligoclase (?) are other similar black crystals. In one place in this slice (B[4]), under a power of 196, was detected a mass having a peculiar structure, as the riband takes an irregular semi-radiating form, in places being somewhat plumose (fig. 15, Pl. 8). As the power is increased it becomes evident that the appearance is due to five crystals being tangled up together; and with a power of 296 the ribands appear to be regular, the curled aspect being due in part to refraction at the junctions of the crystals. Under a power of 386 the whole is seen dotted over with minute black specks, with some short black lines; the specks in some places being more numerous than in others (fig. 16, Pl. 8). Some of these specks, especially those in the upper crystal, are evidently gas bubbles, but more than three-fourths in the whole mass seem to be minute crystals or bunches of crystals.

Fig. 17, Pl. 8, represents another crystal, showing under a power of 296, a somewhat similar construction. In the upper portion the layers are slightly crumpled and crushed up, especially the lower ones. In the small portion to the left hand the lamina run obliquely, while in the crystal to the right hand there was seen by polarized light, a whitish mass traversed most irregularly by blue walls and roundish masses. Under a higher power (386) the composition of the upper and left hand crystals seem similar to that of the five just described, the mass being all dotted over with black specks and gas bubbles; and the irregular mass to the right hand seems to be inclined to have a concentric structure.

B^5. *Porphyritic granite—Kirkullen* (Galway sheet 81). In the field it seems to contain flesh-coloured felspar, light green waxy felspar, quartz, amphibole, black mica, pyrite, small spangles of white mica; crystals of titanite are rare. The flesh-coloured and the light green felspars seem to occur in about equal quantities, but large, usually twin crystals of the first, give the porphyritic character to the rock mass, but some of the light green felspar crystals are large also. The micas, amphibole, and pyrites, occur in nests usually associated with the quartz skeleton, but the micas also occur margining some of the crystals of the green felspar.

Of this rock one slice was cut showing its ordinary character, and from it we learn there are at least three kinds of felspar in the rock, although only two were observed in the field.

Flesh-coloured felspar (Orthoclase). None of the large crystals were examined, but the small crystals and masses seem to be quite different from those observed in the previously examined rock (B^1, B^4, B^3, and B^4), as they contain numerous inlying minerals, similar to the twin crystals in the Knockanavoddy (B^1) and Furbogh (B^3 and B^4) granites.

Pale greenish felspar. This, as it appeared in the field, seemed to be similar to the greenish waxy felspar of the Knockanavoddy granite, but under the microscope we find the mass of it has characters similar to those of the dull white felspar of that rock, but with it are associated crystals and portions of crystals of a triclinic felspar. Under a power of 63, one crystal of this kind of felspar was found to be enveloped in triclinic felspar, and another crystal has a centre and semi-envelope of triclinic felspar, while enclosed portions of crystals of triclinic felspar are not uncommon. Many of the crystals and masses of this felspar are so opaque that their structure cannot be properly seen; this is probably due to the slice not being cut thin enough. Enough, however, can be seen to know that the felspar is similar to those previously described and supposed to be adularia.

Triclinic felspar. This felspar, when the rock was examined in the field, could not be distinguished from the preceding. In the portions of the crystals associated with the adularia (?) the lines of structure are straight and parallel, and the play of colour regular, but this is not the case in the individual crystals and masses. In one crystal, with a power of 196, there are straight, sharp, but not perfectly parallel, lines, while the play of colours is faint. Under a power of 396 the straight sharp lines seem to be due to cleavage or shrinkage lines, and are now filled by thin films of a black mineral; they probably are accidental adjuncts to the crystal. In a second mass of triclinic felspar we find, with a power of 196, that the layers of structure are not parallel, some being inclined to be lenticular, the lines of green and white being short, of different thicknesses, or joining into one another; yet the play of colour is very regular.

XVII.—Granitic and other Ingenite Rocks of Yar-Connaught, and the Lower Owle; or the mountainous tract of country west of Loughs Mask and Corrib. By G. Henry Kinahan, M. R. I. A., F. R. G. S. I., &c., with Plates 9, 10, 11 and 12.

[Read November 13, 1871].*

Object of the Essay.

During an examination extending over seven years on the part of the Irish branch of the Geological Survey of the United Kingdom, of the rocks in the mountainous country west of Loughs Mask and Corrib (parts of the counties Mayo and Galway), certain facts as to their age, position, and relations to one another were gradually developed, and certain convictions as to their origin formed.

In this paper it is proposed to lay before the Academy an epitome of the facts observed;† also some suggestions in regard to the origin of the granites and other ingenite rocks.‡

The latter are specially put forward in the hope that they may be examined and criticised by more competent judges than the author, and thereby their value proved.

In the first part of the paper it is proposed to enumerate and give a general description of the rocks; while in the second part will be found suggestions to account for their origin and relations one to the other.

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* The publication of this paper has unavoidably been delayed by the MSS. having been mislaid after it was referred to Council for publication.

† The details relating to these rocks will be found in the published memoirs of the Irish branch of the Geological Survey.

‡ Mr. D. Forbes has proposed to divide all rocks into two great classes. First, *Ingenite rocks* (born, bred, or created within or below); and second, *Derivate rocks*, "since directly or indirectly they are all derived from the destruction of the former." (*The Microscope in Geology*, by David Forbes, F. R. S., page 6), reprinted from the Popular Science Review, October, 1867. In the first are included all granitic, metamorphic and igneous rocks, while the second contains all sedimentary and other subaqueous or subaerial accumulations. The geological terms necessary for a description of the ingenite rocks have been used by some authors in most conflicting senses, while many rock-names are unintelligible on account of their being given by the many writers to rocks of different characters. In this essay all words of one class will have the same signification. Thus, words ending in *ic* or *ose*, will signify 'belonging to'; as, *Granitic*, belonging to granite; *Schistose*, belonging to schist; and words ending in *oid* will signify 'like'; as *granitoid*, granite-like; *gneissoid*, gneiss-like, &c. Rock-names, except when absolutely objectionable, will be used for the rocks to which they were originally given, but at the same time, to prevent confusion, the ordinary composition of the rock will be stated. Dana's suggestion for an ending of *yte* instead of *ite* for rock-names will be adopted, also his name for minerals.

PART I.

Rock-names and general description.

The ingenite rocks of this area include *Plutonic rocks* (Basic and highly Siliceous); *Metamorphic rocks* (Sedimentary and Igneous), and *Granitic rocks.*

General Table of the Rocks.

PLUTONIC ROCKS.—*Carboniferous* (?) *Whinstones; Post-silurian Whinstones; Llandovery Whindstones; Pre-Llandovery Whinstones; Cambro-silurian* (?) *Whinstones* (Metamorphic); *Post-silurian Felstones; Silurian Felstones* (Llandovery age); *Pre-LlandoveryFelstones; Cambro-silurian* (?) *Felstones* (usually Metamorphic).

METAMORPHIC ROCKS.—*Schist*, including schistose-limestone, schistose-dolomyte, ophyte, and steatyte; *Gneiss; Hornblende rock** (metamorphic whinstone); *Foliated Felstone* or *Gneissyte* and *Granitoid Felstone* (metamorphic felstone).

GRANITIC ROCKS.—*Elvanyte* or *Quartz Porphyry; Oligoclasic*† *Granite; Orthoclasic* or *Highly Siliceous Granite.*

PLUTONIC ROCKS.‡—In the foregoing list the oldest whinstones and felstones, except a few of the latter, are more or less metamorphosed; consequently they do not *now* belong to the plutonic rocks and cannot be described among them, but their descriptions will be found among the metamorphic rocks, under the names, *Hornblende rock, Gneissyte*, and *Granitoid Felstone.* They are enumerated in the list to show their age and origin.

Whinstones.—The term *whinstone* is here used in preference to *greenstone* on account of the varied significations given to the latter. *Naumann* confines the name to diabase; *Brongniart* to dioryte (amphibole + felspar, not orthoclase); *Cotta* includes in his greenstone group, diabase and dioryte; while *Jukes* and many other British geologists included not only all the basic-plutonic rocks or whinstones but also many of the basic felstones (Eurytes of Daubuisson), especially if the latter are of a green colour.

Pre-Llandovery Whinstone.—These rocks seem principally if not wholly to belong to the group of rocks that are included under the general name of *diabase* [pyroxene (diallage generally) + felspar (not

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* This term is used as Macculloch used it.

† These granites were originally called oligoclasic granites, as the waxy felspar was supposed to be oligoclase; now, however, by microscopical examination, it is found to be in part orthoclase, probably adularia. The names, however, may still stand, as oligoclase seems to be an essential element of the rocks, while it is rare in the orthoclasic granite. [*Note while in press.*]

‡ From *Plutus*, the god of the infernal or lower regions, the name having been given to these rocks in contradistinction to the *volcanic rocks* or those formed at or near the present surface of the earth.

orthoclase) + ripidolite]. They are light greenish or purplish to bright green in colour; tough but weather more or less freely; generally have a scaly or mealy aspect; some, however, are compact (*diabase-aphanyte*). They break with an uneven to a subhackly fracture, and fuse more or less readily before the blowpipe. Some diabase is magnetic, due to the rock containing pyrrhotite as an essential (*magnetic* or *pyrrhotitic diabase*); a common variety is highly micaceous (*micaceous-diabase*), while others are both micaceous and pyritic, the latter often weathering into a mica-ferruginous sand which may be magnetic.

Llandovery Whinstone.—Bedded dolorytes in the Toormakeady conglomerates.

Post-silurian Whinstone.—Some of these rocks apparently are very similar to the diabase already described, while in others uralite replaces the diallage (*uralitic-diabase*). Some of the uralitic-diabase seems in places to graduate into a rock apparently a euryte or basic felstone.

Carboniferous (?) *Whinstone.*—The age of these rocks has not been positively proved,* nevertheless, it is evident that they are newer than the rock just described, as in all places where rocks of both groups are associated together the diabase is displaced and cut by these whinstones; moreover, they seem to be newer than all the felstones. They are *dolerytes*, probably *melaphyres* [pyroxene + felspar (not orthoclase) with or without some amphibole]. These dolerytes are from granular to compact, have a glistering resinous lustre, are dark-coloured (blackish, blackish-brown, and dark olive), and tough. The compact, homogeneous varieties (*melaphyre-aphanyte*) have a conchoidal fracture, while the granular rocks break from uneven to subhackly. Some of the melaphyres are porphyritic, while others are more or less micaceous (*micaceous-melaphyre*). In a few were observed siliceous blebs (opal ?); all fuse readily before the blowpipe. When in mass the outside shell of these dolorytes has a peculiar tuffoid aspect and contains few or many zeolites.† All the melaphyres, but especially the aphanytes, usually weather freely, the latter nearly always being in narrow dykes. The free weathering seems in part due to the structure of the rocks, many being very jointy, causing them to break up into small angular fragments. This reticulated structure appears to be caused by a rude columnar structure perpendicular to, and a platy structure rudely parallel to the walls of the dykes. In some of these rocks there is a spheroidal structure combined with the platy (fig. B, Pl. 9), while in others the fragments into which the rock breaks, are found to consist of consecutive layers. In one locality, part of a dyke was found to be amygdaloidal; this structure occurred along a joint in the dyke (see

* My colleague, R. G. Symes, F. R. G. S. I., &c., &c., has proved that whinstones in the neighbourhood of Castlebar, Co. Mayo, exactly similar to those now being described, are of carboniferous age.

† These tuffoid portions may be due to the rock mass being protruded into water; consequently, the outer part would be liable to be pulverised and disintegrated (see page 113).

fig. A, Pl. 9). These whinstone dykes often occur associated with older intrusive rocks, coming up alongside or in them, on which account in some places rocks of quite different ages are found associated together. A whinstone in a granite vein, and this granite vein in hornblende rock, has been observed in various places.

Felstones of post-silurian age.—These felstones are newer than the rocks of Llandovery age; they come up through the silurian, the metamorphic, and the granitic rocks. They are blue, greenish-blue, or grey in colour, from compact to splintery, often more or less granular, and with a fracture from semiconchoidal to uneven. In places when traversing certain argillaceous rock there are no walls to the dykes, the two rocks merging into one another as if the adjoining part of the derivate rock had melted, and thereby been amalgamated with the felstone. Some, if not all, these rocks belong to the *eurytes* or basic felstones (one of the *hybrid-rocks* of Durocher), as splinters fuse on the edge before the blowpipe, some even seeming to graduate into a urilitic-diabase. Others are porphyritic merging into porphyrite; the latter more generally being found as small dykes or as thin portions alongside the walls of large dykes. In the latter case although the major portion of the dyke may be grey or green in colour, splintery or granular in texture, and breaking with an uneven fracture, yet a few inches in thickness alongside the walls will be of a clear blue colour with distinct felspar crystals (a porphyrite), compact and breaking with a conchoidal or subconchoidal fracture. Some of these felstones are so jointy that they break up into an angular shingle or gravel—in some there is a platy arrangement parallel or nearly so to the walls of the dykes, while in others or in parts of others there is an oblique structure, and often between the oblique lines are others perpendicular to them, as shown in fig. C, Pl. 9. At or near the termination of dykes a spheroidal structure is common, more or less combined with a platy arrangement.

Felstones of upper silurian age (Llandovery).—These felstones occur as bedded masses among the rocks of upper Llandovery age and as dykes in the granitic and other hypogene rocks. Among the Llandovery rock they are associated with tuffs, agglomerates, and such like mechanical accompaniments; in places the basal-bed of the Toormakeady and Mweelrea beds is one of these felstones. Among the hypogene rocks the dykes sometimes graduate into *amphibolic-elvanyte.*

These rocks are usually very compact, often cornoid; some, however, are scorious and amygdaloidal; they may be porphyritic or pass into porphyrite. In places when in bed-like masses they have a columnar structure. They are from green to purple in colour; often are quartzitic, especially the purple rocks, containing blebs, globules, and crystals of glassy quartz that usually have a dull pellicle. Before the blowpipe they fuse with greater or less facility, the purple varieties on the edges of splinters, but some of the green rock readily into a bead. All the green varieties are very basic, some indeed appearing to graduate into whinstone. One variety is maculated, roundish and oval dark blue patches occurring in a light purplish blue matrix; these maculæ decompose freely, and give the weathered surface of the rock an irregular honeycomb aspect; they also fuse easily before the blowpipe, but the matrix only slightly on the edges of splinters. There is also a variolitic greenish variety, dark green small concretions in a light green base; this rock is very friable and possibly may be a compact tuff and not a normal igneous rock. All these felstones are basic varieties, the *eurytes* of Daubuisson.* In some of the dykes of *micaceous-euryte* there is a fine platy structure that unless carefully examined may be mistaken for foliation. In different places in this area, but very numerous in the west part of the barony of Ballynahinch, are dykes of basic-elvanyte; these in places seem to graduate into these eurytes, and probably were the roots or deep-seated portions of the upper silurian felstones.

Pre-Llandovery felstones.—The rocks of this age only occur as dykes and intrusive masses in the hypogene rocks. For the most part they seem to be *petro-silex* or the rocks called *felsyte* by Dana, Cotta, Forbes, and others. Some are cornoid, others saccharoid in appearance; usually the constituent are undeveloped, save the quartz, which appears in some as blebs, globules, and crystal often very minute (*quartzitic-petro-silex*). Some of the saccharoid varieties graduate into a rock very similar in aspect to the *felsitic-granite* described hereafter. Either kinds may become porphyritic and micaceous, and through that graduate into elvanyte. In some of the cornoid petro-silex there is a riban of different colours or of dark and light shades of one colour (*riban petro-silex*), while along the riban the rock has a tendency to split into plates or slabs; these rocks are often quartzitic. A common variety of petro-silex is of a whitish pink, greenish blue or greyish colour, subtranslucent, homogeneous, compact, breaking with a conchoidal fracture, and weathering with a thick white crust. This variety, although compact, is often effected by three or more systems of close jointing that cause it to break up into angular shingle, often partaking more or less of a cubical form. When not jointed this variety weathers with a remarkable smooth even surface.

Cambro-silurian felstones.—In the country north of Killary Harbour, associated with partially metamorphosed sedimentary rocks are felstones (also in places partly altered) occurring in protrusions and in dykes. The rock when unweathered is usually of a bright green or grey colour; it, however, weathers easily into a dirty cream-coloured rotten rock. In the dykes this felstone often has a peculiar brecciated structure having an appearance more like a coarse tuff or a fault-rock than a normal felstone; nevertheless, in other parts its true character is

* Naumann and Cotta propose to call these varieties *Porphyrites.* It, however, is a most inappropriate and confusing name; for in the first place, as Cotta himself points out, "*the name of porphyrite refers to a texture which is not an essential feature of these rocks, because the porphyrites are not always in fact porphyritic;*" and in the second place, porphyrite and porphyry are used synonymously by many petrologists, Cotta even so using it.

indisputable. When in protrusion a considerable portion of the mass will be a scaly or mealy, friable, tuffoid rock; some parts, however, will be compact, and all will be more or less unctuous as if the rock was merging into *steatyte*. These rocks must be very ancient compared with the rocks last described, as they were intruded prior to the metamorphism of the associated rocks.

HYPOGENE ROCKS.—The hypogene rocks include the metamorphic and granitic rocks given in the general table. In the country west of Loughs Mask and Corrib the development of these different rocks is well shown, as normal sedimentary, or derivate rocks first become partially metamorphosed (*schist series*); secondly, the alteration becomes more decided (*gneiss series*); and thirdly, they are entirely changed (*metamorphic and intrusive granite*). Intervening between the typical granites and the plutonic rocks are found the *elvanytes*. It has previously been shown that the plutonic rocks graduate into elvanyte and hereafter it will be pointed out that the latter rocks graduate into the intrusive granite, and through that into the metamorphic granite. The rocks composing the *schist-series* are for the most part schist; nevertheless, in them are subordinate beds of gneiss, on account of some rocks being more susceptible of change than others, while in others the constituents of gneiss (quartz + mica + felspar or felsite*) already existed. The latter, however, are seldom typical gneiss, that is, having these constituents arranged in leaves or plates, but rather the minerals are more or less irregularly mixed together, only an incipient foliation being developed. Similarly in the *gneiss-series* there are subordinate beds of schist, as some rocks on account of their constituents are less susceptible of change than others; while associated with the rocks of both the schist and gneiss-series are metamorphosed igneous rocks.

When the rocks begin to be altered, the planes of the most marked structure in the original rock are more or less glazed or micacised, and the mass indurated. In argillaceous rocks the surfaces of joint lines, breaks, or fissures are hardened and in some cases these, originally open lines, are sealed; or the sides, varying from a film to two or three inches in width, are hardened, seemingly by being impregnated with some such substance as silex in solution. On the surfaces of some rocks, crystalline lines about the size of whipcord form, sometimes straight but often vermicular; moreover, such minerals as phylite, chiastolite, pyrite, and the like, are developed indiscriminately through the mass of the rock or on the structural planes, being most conspicuous under the latter circumstance. A primary change, prevalent in arenaceous rocks, is a more or less scaly or fissile structure being developed, while others become variolitic or maculated, all being more or less indurated and glazed on

* *Felsite* is the mineral, an amalgamate of felspar and silex, while the rock will be called *Felsyte*.

the structural planes.* Gradually the rock becomes typical schist, when in some of the micasyte, talco-micasyte, and talc-yte, a peculiar frilled or sharply crumpled struction is developed. This structure is very remarkable, as no structure similar to it occurs in the unaltered rocks. Moreover, it seems to disappear in the last stage of metamorphism as it has not been remarked in any of the rocks of the gneiss-series. In some of the quartzytes or quartz-schist there is also a peculiar structure, having an aspect scarcely distinguishable from the planed, polished, and etched surfaces due to ice action. This, however, always occurs only on the original planes of stratification, and if the rock is flaggy and is split into plates the surface of each plate will be a counterpart of that above it, from which it would appear this structure is probably due to a cleavage in the original rock. If this was the case all other traces of the cleavage have now disappeared, as the present rock has no tendency to split except along the planes of deposition.

The schists graduate into gneiss and the gneiss through granitoid-gneiss or gneissoid-granite into typical granite.

The granitoid-gneiss has a foliation peculiar to itself. In all the other rocks belonging to both the schist and the gneiss series the foliation appears always to follow the most prominent structure in the original rock, let it be fine-jointing, cleavage, or lamination, whether the latter is parallel, oblique, curled, spheroidal, concretionary, nodular, or conglomeritic.† In granitoid-gneiss other laws seem

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* The partially altered grits and sandstone called by Macculloch "Primary Sandstone," (*A Geological Classification of Rocks, &c.*, by John Macculloch, M. D., F. R. S., &c., page 331), are largely represented in the country west of the northern end of Lough Mask. Associated with them are subordinate beds of micasyte argillyte and clay-slate, while towards the west they graduate into quartzyte. The clay-slate and argillyte are due to the metamorphism of argillaceous rocks, while in this locality much of the micasyte was originally a micaceous, obliquely laminated sandstone, and in the schist it is quite apparent that the foliation has been induced by the oblique lamination. The "Primary Sandstones" are, for the most part, massive, compact, and hard, generally very arinaceous, but sometimes felsitic; rarely are they gneissoid. As they graduate into quartzyte a fissile structure is developed parallel to the stratification planes; they are generally of a reddish or purplish colour.

† The frilled or sharply crumpled structure previously mentioned, in some micasyte and talcytes, is the only exception to this general rule that I have detected. A crumpled lamination occurs in some unaltered argillaceous rocks, to which, in another place, I drew attention (*On Crumpled Lamination in Shales*, Journal Geol. Soc., Dublin, 1863); but that has its representative among the foliation. This also I have previously pointed out (*Notes on the Foliation of the gneiss and Schist of Yar-Connaught*, Journal Royal Geol. Soc., Dublin, 1866). Moreover, it has not an aspect analogous to this structure; furthermore, it is rare, while this is not uncommon. In schistose-limestone, schistose-dolomyte, and ophyte, there are very complicated foliations, and at one time I was inclined to suppose they must be due entirely to the metamorphic action. This, however, I find not to be the case, for, on a careful examination in many places of unaltered limestone, I find that, as a general rule, it is always more or less affected by all sorts of irregular structures not

to be in operation. The foliation is linear, parallel, and perpendicular, or nearly so, and in general the only original structure that seems to affect it, seemingly, is the strike of the stratification. As the gneiss became more and more granitoid, and perhaps also granitic, the original structure gradually became obliterated, and the foliation more and more perpendicular.* The only other structure that in places seems to resist the change is that of the conglomeritic gneiss. Usually the contained blocks in the latter, as the rock changes from schist to gneiss, become elongated, with the foliation curling more or less regularly round them (fig. F, Pl. 9); and as the rock graduates into granitoid-gneiss a linear parallel foliation is developed, obliterating the conglomeritic foliation, the matrix becoming a more or less fine gneiss, and the contained blocks coarse gneiss, the margins of the latter, as shown in the sketch (fig. D, Pl. 9), being still traceable; but eventually one kind merges so completely into the other that, except on very minute examination, no difference will be observed. This, however, is not always the case, for, in some places, the enclosed blocks will remain distinct in both composition and aspect; moreover, these will deflect the foliation in their vicinity, it curling round them. Furthermore, these blocks, although generally more or less elongated, will not always be so modified, as in a few rare instances they were remarked to be more or less angular, the latter even having been observed in the intrusive oligoclasic-granite (see fig. E, Pl. 9.) In the common gneiss of the gneist series, felspar and felsite, or even only felsite, may be present associated with the mica and quartz; but in the granitoid-gneiss all the constituents seem to be developed in regular crystalline particles, no felsite matter remaining, it all having been developed into quartz and felspar, and hereafter the microscopist may prove that the granitoid-gneiss ought not to be kept in the gneiss-series, but rather included among the granites, and called *Foliated* or *Gneissoid-granite*. Nevertheless the granitoid-gneiss, or the gneissoid-granite, will always be the passage rock between the gneiss and the typical granite. The accompanying section (fig. R, Pl. 12) shows the passage from the schist into typical granite.

METAMORPHIC DERIVATE ROCKS.—*Schist.*—The most conspicuous rocks of this class that were noted in the area to which this essay refers are:—*Argillyte*, or *Argillous-schist*, *Micasyte*, or *Mica-schist*, *Quartzyte*, or *Quartz-schist*, *Hornblendyte*, or *Amphibole-schist*, *Chlorityte*,

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generally conspicuously developed, but sufficient to induce foliation, and similar in their sinuosity and vagaries to those found in the schistose-limestone, schistose-dolomyte, and ophyte.

* In the Geology and Zoology of Abyssinia, p. 169, Blanford calls special attention to the regular and nearly perpendicular foliation in the gneissic rocks, not only of that country but also of western India. That observer suggests that it is due to cleavage in the original rock. This, however, to me seems improbable, as one and the same cause probably affect both the Irish and the African rocks, and in Ireland it was not cleavage.

or *Ripidolite-schist*, *Talcyte*, or *Talcschist*, *Felsityte*, *or Felsite-schist*, *Schistose-Limestone*, *Schistose-dolomyte*, *Ophiolyte*, or *Serpentine*, and *Steatyte*.

Argillyte.—Typical argillyte is an argillous rock, in which the planes of lamination are more or less glazed, and also often the planes of cleavage, but not always, as some slates belonging to the metamorphic series have a more or less earthy cleavage surface. The most common of the varieties in this area seems to be *Chloritic-argillyte*, *Clay-slate*, *Steatitic-argillyte*, some of which might be called *Steatityte*, or *Steatite-schist*, *Hornblendic-argillyte*, *Arenaceous-argillyte*, *Calcareous-argillyte*, *Dolomitic-argillyte*, *Ophiolitic-argillyte*, *Pyritic-argillyte*, and *Chiastolitic-argillyte*. Structural varieties are *coarse*, *fine*, *crumpled*, *spheroidal*, *concretionary*, *nodular*, *conglomeritic*, *knotty*, full of small nodules or concretions, giving the rock a knotty aspect, *irregular*, *oblique*, and *ribaned*, the latter variety being rather common.*

Micasyte.—This rock is *par excellence* the typical schistose rock of the country, its varieties in composition being nearly innumerable, and some one or other of these varieties graduate into one or other of every kind of schist. In composition the principal varieties are *argillous-micasyte*, *two-micasyte*, *quartzitic-micasyte*, *hornblendic-micasyte*, *chloritic-micasyte*, *talcose-micasyte*, *garnetiferous-micasyte*, *felsitic-micasyte*, *calcitic-micasyte*, *dolomitic-micasyte*, *ophiolitic-micasyte*, and *pyritic-micasyte*. Any of these varieties may graduate in one of the schists hereafter enumerated; moreover, two or more of these varieties may be combined, forming endless sub-varieties.

Micasyte has similar structural varieties to argillyte, and in addition to these the peculiar frilled structure previously described is common; also, it may be gneissoid, through which it graduates into gneiss. Two subvarieties of quartzitic-micasyte deserve special mention and description. One is *fibrous-micasyte*, in which the quartz is arranged in thin stalks or layers, giving the rock a woody aspect. In some the stalks are long and irregular, while in others they are more or less ovate. When the inliers of quartz are oval, a cross section of the rock has a marked character forming a more or less regular net-work. In the second there are small, thin, round, slightly elongated discoid pieces of quartz scattered through the rock, sometimes sparingly but often thickly together. The rock when weathered has the appearance of being scattered over or stuck full of small pieces of money from the size of a silver penny to that of a sixpence, from which the rock might be called *nummoid* or *money-schist*. The fibrous and nummoid-schists graduate into one another.

Quartzyte or Quartz-schist.—Quartz-schist to me seems to be given a prominence to which it is not entitled, as quartz-schist among

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* Other varieties may occur, but in this and all other lists only the rocks observed are mentioned. Particular descriptions of the varieties are unnecessary, as they will be found in the different works on Petrology; therefore, in this essay, the only varieties that will be minutely described are those that are peculiar.

other schist is not even analogous to grits or sandstones in a group of sedimentary rocks, for all grits and sandstones are not metamorphosed into quartz-schist, many changing into mica or other schists. In this area the quartzyte has no true boundary, as both in depth and length it graduates into other kinds of schist, and no matter how characteristic some portions of a series may be, other parts will be so micaceous or felsitic, &c., &c., that except for their associates they would never be classed as quartzyte.*

The quartzytes generally are pale-greenish or white in colour, but some are greyish, blueish, reddish, or blackish; compact, hard, but brittle; when fractured, often have a saccharoid aspect, and usually have a glimmering vitreous lustre. Few of these rocks are without flakes or plates of mica, generally white, on the surface of the stratification or lamination planes; some, however, are more or less massive, and in them the mica is not very conspicuous. Many of the quartzytes are affected by irregular joint system, on which account, when exposed to atmospheric influences, they break up readily into angular shingle. Some are ribaned, bands of different colours alternating; many of them seem capable of being split into flags, which is rarely practicable, on which account they are locally called *lack-avrea*, i. e. tangled flags.

In places in this area, a not uncommon variety of this schist is *felsitic-quartzyte*, an aggregate of quartz and felsite. This often occurs as a massive or thick-bedded rock, and sometimes, as will hereafter be more fully stated, it may possibly not be a metamorphosed derivate-rock (see page 130). Felsitic-quartzyte may graduate into *felsityte*, while ordinary quartzyte generally merges into *quartzytic-micasyte*. It has been pointed out that usually a series of quartzytes graduates into one or other of the different groups of schist; there is, however, one remarkable exception, as lenticular masses and subordinate beds of *hornblendyte* are not uncommon among the quartzytes of Yar-Connaught, and between these two kinds of rock there is nearly always a hard abrupt boundary. These subordinate beds of hornblendyte will again be mentioned.

Hornblendyte or Amphibole-schist.—Hornblendic-micasyte graduates into hornblendyte, while the latter often merges into *chlorityte* or *talcyte*. The most interesting of all the schistose rocks in Yar-Connaught are the hornblendytes, as they for the most part must originally have been tuffs or tuffose rocks, as they are intimately asso-

* There are some rocks called quartzyte (the *Quartz-rock* of Jukes) such as those at Bray Head, Co. Wicklow; to these, however, I do not refer, as I believe that they and ordinary quartz-schist belong to quite different classes of rock. From my above remark I do not mean to say that in mapping a country the quartzyte ought to be ignored; on the contrary, I always advocate that any remarkable beds, no matter how insignificant, ought to be traced out if the geology of the area is to be properly ascertained. But I do object to hypothetical boundaries being laid down; and if quartzyte is to be given a *hard* boundary and a separate colour on geological maps, so ought micasyte, hornblendyte, felsityte, &c., and every bed of sandstones or grits among sedimentary rocks; the absurdity of which must strike everyone.

ciated with bedded and intrusive masses of ***hornblende-rock***. Of such rocks Jukes says: "It is very possible that many hornblende-schists, actinolite-schists, &c., are metamorphosed tuffs."* Of tuffs and tuffose rocks Forbes thus writes—"Subaerial or subaqueous outbursts may force into the sea irruptive rocks, which, being at once broken up into a state of division, more or less fine in proportion to the greater or lesser cooling power of the water-mass in immediate contact, may be spread out into beds by the action of the waves. The texture of these rocks may vary from that of the coarsest breccia down to the finest mud, and, as is usually the case, such deposits may present themselves as alternating beds of coarse and fine character. Upon the consolidation of such formations, rocks are formed identical in chemical and mineralogical composition with the original irruptive rock from which they were derived, and which, particularly when close-grained, often present an external appearance so like the original rocks as to be frequently undistinguishable from them by the naked eye."† Scrope and the other historians of the volcanic regions mention the accumulations of agglomerates and other tuffose rocks often associated with volcanic-rocks, while in various places in Ireland, such as the plain of Limerick and the vicinity of Valencia Harbour, Kerry, there are similar accumulations associated with plutonic rocks; therefore, it does not appear at all improbable that these ancient exotic rocks of Yar-Connaught should also have had associated tuffs and other such mechanical accompaniments.

The hornblendytes of Yar-Connaught range from a fine, almost compact, rock to a massive conglomeritic rock containing enclosed masses or blocks often yards in width.

The conglomeritic-hornblendyte is always more or less associated with protrusions or beds of hornblende-rock. In places they graduate into one another through a nodular or spheroidal variety of the latter, while the conglomeritic-rocks, on the other hand, gradually loose all their blocks and merge into ordinary schist. In others, the hornblende-rocks and the conglomeritic are intermingled together irregularly, and the mass formed of both combined, will be surrounded by the regular stratified rocks of the country. This would seem to be additional proof if any more is wanted, of these rocks originally being tuff and agglomerates; for such a mass as that represented in figs. Q, Pl. 11, and R, Pl. 12, may well be considered the remains of an accumulation formed around a subaqueous plutonic vent.

In the immediate vicinity of a mass or tract of hornblende-rock the enclosed blocks in the conglomerate will be, for the most part, some one or other variety of igneous rock, some having an aspect like scoria or pomice. Farther away they will be mixed with blocks of one or more other kinds of rock, and eventually all the blocks will gradually disappear and the rock graduate into an ordinary schist. In one locality

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* *Manual of Geology* by J. Beete Jukes, M. A., F. R. S., second edition p. 82.

† *The Microscope in Geology*, p. 10.

blocks of felstone were observed in a conglomeritic schist; these were not only remarkable but highly instructive, for they not only proved that felstones must have existed prior to the formation of this sedimentary rock, but also that some felstones are less susceptible of change than whinstones, for while the matrix was a well marked schist, and in the associated blocks, mostly hornblende-rock, there was more or less foliation, these were very similar to ordinary felstone, the only alteration that was evident being an almost microscopic foliation, obscurely visible to the naked eye, on weathered surfaces.

The foliation in the conglomeritic-schists is irregular. That in the enclosed blocks may run in various directions, while that of the matrix has a greater or less tendency to curl round the blocks, but in some cases it is very irregular (fig. F, Pl. 9).

The fine hornblendyte is often more or less associated with hornblende-rock. Sometimes the latter rock at the margin graduates into it, when it is impossible, except pieces of the rocks have been subjected to microscopic examination, to say where one rock ends and the other begins; while at other times it occurs as lenticular patches or layers enclosed in the mass, or as thin partings. In such cases it is probable they were formed from the disintegrated portions of the original igneous rock due to its contact with water, the enclosed layers and patches marking the limits of different flows or beds.* Fine hornblendyte may also occur as independent beds when it often graduates into chloritytc, talcyte, steatityte, or hornblendic-micasyte, but it is most remarkable when it appears associated with quartzyte, for, as previously remarked, in such places it rarely graduates into that schist, such masses apparently being due to showers of tuff falling on water and settling down in one place, forming a distinct, small, but independent, patch of rock. All the fine hornblendytes are more or less epidotic or they may change into a rock that might be called *epidoticyte.*

The weathering of these fine schists and also many other varieties of schist that are more or less basic should be noted, for in them the old joint lines seem to have been cemented or sealed, while layers of rock in juxtaposition to the joint lines have been hardened, thereby causing on weathered surfaces more or less angular figures (figs. G, H, Pl. 9, and P, Pl. 10). In the more siliceous rocks the old lines are not so often cemented or sealed, but it is not uncommon even in granites to find, adjoining to the joint lines, layers indurated, apparently silicified (fig. H, Pl. 9).

Chlorityte, Talcyte.—These rocks seem to be very much allied, as one rarely occurs without the other. Some were observed to be tourmalinic, others garnetiferous. They graduate into varieties of micasyte and into hornblendyte.

Felsityte.—This schist has, besides others, two marked varieties,

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* Tuffose layers between flows or beds of plutonic rocks are found in Cork, Kerry, Limerick, and other places.

namely, the fine compact and the scaly friable. The fine rock has an aspect very similar to quartzyte, but distinguishable from that schist by its always weathering with a white crust similar to felstone. The scaly or friable felsityte seems for the most part to be an aggregate of minute felspathic flakes or scales; nevertheless, it is very tough and hard to break across, but along the grain can be split with greater or less facility; across the grain it breaks with a hackly fracture. It is always more or less steatitic. This variety of felsityte sometimes occurs as a stratified rock, but in the country north of Killary Harbour it undoubtedly is in places part of an intrusive mass, being the tuffoid portion of the hereafter mentioned felstone protrusions, which rock having been metamorphosed is changed into these schists. It may be here suggested that all the felsitytes and perhaps also the felsitic-quartzytes are probably metamorphosed felsitic tuffs and tuffose rocks. These rocks, however, will hereafter be more fully considered.

Subordinate schists which claim separate descriptions are *pyrrhotityte* or *pyrrhotite-schist* and *rhætizityte* or *magnesian-schist* on account of their remarkable composition, the former also having been worked for the minerals it contains.

Pyrrhotityte, when typical, is a crystalline aggregate of quartz, pyrrhotite, pyrite, and chalcopyrite, with a little mica. As the mica increases in quantity the sulphides decrease until eventually the rock passes into mica-schist. In some varieties the mineralogical metals predominate to the nearly total exclusion of all others; however, it is very variable in its composition, having many accessories, and changing rapidly from a highly metalliferous to a non-metalliferous rock.*

Rhætizyte or *Magnesian-schist.*—This was only observed in one locality (Cannaver Island, Lough Corrib). Of specimens of the rock Mr. Forbes says—"Very identical with one described by me in Norway."†

Schistose-limestone, Schistose-dolomyte, Ophiolyte, and Steatyte.—These rocks, although different in aspect and composition to all other schistose-rocks, must be classed among them, as they graduate into some one or

* Here it may be mentioned that in connexion with these schists there are metalliferous lodes evidently older than the associated granite-veins, and apparently of metamorphic origin. These consist of a crystalline aggregate of pyrrhotite, pyrite, chalcopyrite, quartz, mica, orthoclase, and oligoclase, with marcasite, amphibole, &c., as accessories. Adjoining such lodes more recent lodes usually occur. There are also veins of *garnet-rock* which seem to be connected with the metalliferous strata, as they were not noted in any other parts of the country. This vein-rock is a more or less crystalline mass of brown garnet; when very crystalline it usually contains crystals of pyrrhotite, pyrite, chalcopyrite, quartz, oligoclase, &c., with the interstices filled with epidote and ribaned pearl-spar. Some fine crystals of the epidote have been observed. The garnet crystals vary in size, some being over an inch in diameter.

† For the description of the Norway rock, see Quar. Jour. Geol. Soc., Lond., August, 1858.

other of the previously described schists, and eventually when more highly metamorphosed they appear to lose their individual character.

All the limestones and dolomyte* to be described are more or less schistose, yet in many, the calcareous or dolomitic ingredients seem to predominate to the nearly total exclusion of all others. This, however, may be more apparent than real, and in such rocks the different foreign substances may be amalgamated in the mass; for the purest of these limestones, as compared with the carboniferous limestones, give in the proportion of 1·5 to 2·5 or 3 of lime, equal quantities of both being burnt.

The limestone may be white and of a saccharoid aspect. This is sometimes a handsome stone, but in many cases it is impregnated with pyrite or marcasite, and consequently, when exposed to atmospheric influence, it becomes discoloured. These white varieties occur in various places, but the common colour of the schistose-limestone are shades of blue and grey. The magnesian-limestone is usually white or pale dove-colour; the white rock is sometimes dolomyte, but not always, as many are calcitic-dolomytes. The pale dove-colour rocks seem generally to be a mixture of calcityte and dolomyte. Sometimes the calcityte will occur in streaks, layers, specks, or patches in a dolomitic mass, or the dolomyte will similarly occur in relation to calcityte. One variety of the dolomyte is a milk-white, compact, homogeneous fine-stone, breaks with a conchoidal fracture, has externally the aspect of alabaster, takes a fine polish, but is hard and somewhat difficult to cut.

The pale dove-coloured dolomyte and the calcitic-dolomyte appear to be the parent rocks of the ophiolytes and ophicalcytes, commonly known as "Connemara serpentine or marble;" both of these rocks in places occur in mass. At the surface of the ground the purest rock seems always to occur; some, apparently, answering Dana's description of *precious serpentine*. This rock in depth seems to graduate into dolomyte and calcitic-dolomyte. Similarly at the surface ophicalcyte may occur, while in depth it seems to merge into calcitic-dolomyte. The colours of the serpentines are various, dark green, nearly black, pale green, greenish yellow, streaked, ribaned, variegated, maculated, and variolitic varieties having been observed, the combinations including different shades of green, yellow, white, grey, and blue, with, on rare occasions, red, separately or combined.†

Associated with the ophiolytes and ophicalcytes are *ophitic* and *steatitic-schists*, and in some places *steatyte;* these sometimes are of considerable thickness. There are also green unctuous schists that may possibly be *smaragdityte* or *smaragdite-schist.*‡

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* Dolomyte is the rock, dolomite the mineral.

† Ophytes also are found in Yar-Connaught. They, however, are pseudomorphose igneous rocks and will be described with them.

‡ These latter rocks seem to be described by COTTA as a variety of *eklogyte*, but typical eklogyte seems to be a pseudomorph ingenite rock.

Gneiss.—Gneiss, as previously stated, ranges from schistose to granitoid in structure. They may be *fine*, *platy*, *ribaned*, *compact*, *coarse*, *fibrous*, *granitoid*, *porphyritic*, *nodular*, or *conglomeritic*. The four first varieties usually are characteristic of the schist-series, in which they occur as subordinate rocks. In the ribaned all the constituents are of small sizes and form thin even layers; the fibrous has a structure somewhat similar to fibrous schist; the granitoid and porphyritic varieties seem generally to occur together, while most of the nodular and conglomeritic gneiss seems to be metamorphosed agglomerates.

In composition, gneiss may vary from highly siliceous to basic. Rarely is it typical, that is, being composed only of plates or layers of quartz, felspar, and mica, as various other minerals will also be present, sometimes only as accessories, but generally as essentials in addition to or in part replacing the typical constituents. On this account the varieties and sub-varieties are numerous, the following being the most remarkable—*quartzitic*, *felsitic*, *micaceous*, *hornblendic*, *chloritic*, and *pyritic*, the rock being named after the mineral that is more developed or more conspicuous than the others, giving a character to the mass.

Hornblende-rock.—This rock is found as a bedded rock also in dykes and intrusive masses. Associated with it are schist and gneiss, the rocks from which it was formed evidently having been intruded contemporaneously with the deposition of the original sedimentary rocks. Also associated with these rocks are granites that are supposed to be metamorphosed felstones; consequently, it would seem that some of these granite veins are older than some of the hornblende rock. This, however, is more apparent than real. Both kinds of rock (whinstone and felstone) seem to have been ejected at different intervals during the accumulation of the sedimentary rocks, but all were metamorphosed at the same time, the basic igneous rocks being changed into hornblende-rock, and the highly siliceous rocks into granitic or granitoid-rocks, on which account it is evident such granites cannot be older than the hornblende-rock, while the rocks from which the latter were formed must have been intruded prior to the granite that was intruded during or subsequent to the metamorphism of all the rocks.

Hornblende-rock varies much both in structure and composition, apparently according to the nature of the original rocks; still, however, all the varieties may conveniently be grouped under this old name of Macculloch.*

Large protrusions of plutonic rocks in other localities, especially if in part bedded masses, vary much in composition, part being eurytes (basic felstones), and part whinstones, both often occurring associated together. Such would also seemingly have been the original condition of the igneous rocks of Yar-Connaught, in part occurring as outbursts and dykes, in part as bedded masses, and the latter

* See Handy Book of Rock Names, by the writer (Hardwicke, 1873), p. 61, et seq.

associated with tuffs and agglomerates, while in composition they varied from felstones (probably as in the Co. Limerick and elsewhere more or less basic) to whinstones, and the different varieties of the original rocks are now recorded by the variations in the metamorphic rocks. The most common rock of this class in Yar-Connaught appears to be an aggregate of crystals of amphibole, bluish or greenish felspar, pyrite or marcasite, and a little ripidolite, mica, or such like as accessories. It may be from finely to coarsely crystalline. Some are so fine and compact that they might be called *hornblende-aphanyte*. Others are an aggregate of crystals of amphibole, often apparently to the nearly total exclusion of all other minerals. When very coarse the crystals vary from two to four or five inches in length. These rocks seem to be the typical *hornblende-rock* of Macculloch, Haughton, Dana and others. A variety not uncommon has well developed crystals of felspar, not orthoclase (*dioryte*);* while in another variety the felspar is orthoclase (*syenyte*), quartz also often being present, not necessary as an essential but rather as an accessory ingredient. One sub-variety of the syenyte is remarkable, the orthoclase being developed to the nearly total exclusion of the other minerals, the rock being a whitish or flesh-coloured mass through which crystals of amphibole are scattered; this sub-variety (*felso-syenyte*) was only observed in very subordinate quantities. Some hornblende-rock has orthoclase in addition to the other felspars; in a variety, Messrs. Forbes and King (India) called *hyperyte*, hyperstene replaces the amphibole. As some of these hornblende-rocks are metamorphosed diabase [pyrovene (diallage) + felspar (not orthoclase) + ripidolite], portion of the diallage may remain unaltered, or portions may be replaced by hyperstene or an allied mineral, thereby forming various complicated sub-varieties of the rock.

In some varieties of hornblende-rock mica occurs as an accessory, but in others as an essential (*mico-hornblende-rock*). Commonly it is a small black or blackish brown mica occurring more or less abundantly, but besides black, white, pale sea-green, bronze, and reddish violet have been observed.† Some of these rocks seem to answer the description for *kersantyte* of Delesse. The white and the pale sea-green mica generally occurs in large flakes, while the bronze and reddish violet

* (Gr. *dioras*, a clear distinction). I would suggest that it was to rocks of this class the name was originally given, as in them the minerals are always quite distinct.

† Mico-hornblende-rock is called by some "micatrap." This classification appears to be very vague, and evidently the group is not a petrological division. Under this name they include *minnette* or micaceous-felstone and micaceous-elvanyte, *kersanton* or micaceous-dioryte *kersantyte*, or micaceous-diabase, micaceous-melaphyre, micaceous-doleryte, &c., &c., rocks belonging to quite different groups. Moreover, part of a dyke in accordance with this classification might be a mica-trap, while the rest of it belonged to a different class, or, what is not uncommon, the margins of the dyke might be mica-trap, while the centre was doleryte or dioryte or felstone or euryte or elvanyte.

usually is developed in small pockets, distributed regularly and abundantly through the mass. As the mica decomposes more readily than the other constituents, weathered surfaces of these mico-hornblende-rocks have peculiar appearances. If the mica occurs in pockets or nests, the rock surface becomes coarsely pitted (see fig. I. Pl. 9), while if it is developed in large flakes, the rock when weathered presents surfaces on which are rude characters having a more or less angular arrangement, as represented in the accompanying sketch map (fig. J, Pl. 9) of a portion of a rock containing large flakes of silvery white mica. Such varieties of the hornblende-rock are easily recognised on account of the peculiar weatherings.

The varieties of hornblende-rock in places graduate into a granite similar to the rock called *Galway-type granite* in the memoirs of the Irish branch of the Geological Survey. Its description will be given hereafter.

Actinolite or tremolite, wholly or in part, may replace the other amphiboles, and the rock may consist of numerous hyaline acicular crystals mixed with a felspathic paste, or numerous nests of such crystals may occur in an amphibolic-felspathic matrix.

The actinolitic and tremolitic-hornblende-rocks are more or less ophitic, or graduate into *ophyte*, *steatyte*, and such like rocks, the gradation being very apparent among the rocks of the previously mentioned Cannaver Island.

The *ophyte* of this area, due to the decomposition of igneous rock, is usually of a dark leek-green, approaching black, colour, nevertheless a few subordinate patches of a light green were noted; always it is more or less associated with hornblende-rock in places having subordinate beds or layers interstratified; the passage-rock between the two may be called *ophitic hornblende-rock* or *amphibolic-ophyte*, according to the mineral predominating. In some of these passage-rocks crystals of amphibole occur in an ophitic matrix, or blotches or maculæ of ophyte may be developed in an amphibolic base, or ophitic and amphibolic particles may be more or less intimately mixed together. In some it is evident that a hornblendic mineral has produced the ophyte, while in other rocks it seems to be a pseudomorphism of a felspar. In some of these rocks, flakes of a mineral, in aspect like diallage, were observed.

Massive ophyte is divided by Dana into *precious* and *common*. The first "is of a rich oil-green colour, of pale or dark shades, and translucent even when in thick pieces." The second "is of dark shades of colour, and subtranslucent. The former has a hardness of 2·5—3; the latter often of 4, or beyond, owing to impurities." In west Galway, among the rocks of intrusive origin, no *precious* or *noble serpentine* was observed.

A rock allied to those just described, and evidently a pseudomorph of hornblende-rock, has a bright green colour, and an unctious, compact, homogeneous, tough matrix, in which are imbedded more or less irregular crystals or crystalline patches of garnet, flakes of mica, with crystals of cyanite; pyrite may also be detected in it. A specimen of this rock was determined by Mr. D. Forbes to be *eklogyte*, while Mon. A. Gage says it does not present the physical characteristics of that well-known rock, but properly belongs to the serpentine series.

Steatyte occurs as subordinate quantities associated with the ophyte, usually at the margin of masses, or in lenticular patches or irregular veins; however, in other places it appears in mass. When freshly broken it is of a pale greenish grey colour, but becomes a pale bluish grey shortly after being exposed to the air; and subsequently decomposes into a rusty white or dirty cream-coloured substance. It is more or less fissile, very unctious, tough, splits along the grain, but across it breaks with a hackly fracture.

Steatyte in mass in places graduates into felsityte or hornblendyte. In the country north of Killary bay, the previously mentioned tuffoid portions of the protrusions of felstone (p. 114) graduate through felsityte, and steatitic-felsityte into steatyte, while on Bofin and Sharke islands the steatyte is associated with hornblendyte and talcyte, and the mass formed of these rocks combined appears to come up as a protrusion among the metamorphosed sedimentary rocks, while in the protrusion are peculiar irregular pipes, and bomb-shaped masses of compact hornblende rock (*Hornblende-aphanyte*). (See fig. K, Pl. 10.)

From these circumstances I am led to suggest that the steatyte was originally fine tuff, either basic or felspathic, in which were pipes and irregular veins of igneous rocks, the remains of an accumulation formed in the vicinity of a subaqueous plutonic outburst, similar to that previously mentioned when describing the hornblendytes (p. 116). These masses would seem not to have been intruded up among the sedimentary rocks, but rather to have been protrusions, that subsequently were in part denuded away, while round them the sedimentary rocks were being deposited, till eventually the latter enveloped them.*

* In favour of this suggestion it should be stated that, in the places where hornblende rock, in combination with hornblendyte and conglomeritic-schist, form masses that are protrusions in the associated gneiss and schists, the latter rocks seem to be allied to them, having originally been formed of somewhat similar materials. In the neighbourhood of the protrusions of steatyte on Bofin and Sharke, the schists are, more or less, hornblendic and talcose, and in the country north of Killary harbour the schists in the neighbourhood of the felspathic mass are, more or less, felspathic, many of them being felsityte. This should be expected if the above is correct; as part of the accumulation of tuff would remain as an irregular mass, while the portions destroyed by denudation should be deposited around the residue; and, although not exactly similar, yet, in a great measure, partaking of its nature. To account for the rocks north of Killary harbour, we might suppose a protrusion of felstone somewhat similar to one of these in Auvergne, except that, instead of being subacial, it was subaqueous; the outside portion of such a mass would be, more or less, disintegrated, and pulverised, during the cooling process, by the water-mass in contact, and thereby produce materials that, when deposited around, would form rocks very similar in composition and aspect.

The hornblende-rock often merges into a nodular variety, or, as previously stated, it may graduate into hornblendyte. (See figs. L, M, and N, Pl. 10).

Often between it and the hornblendyte there is no rigid boundary, their mineral composition apparently being identical, on which account the derivate rock would seem to have been formed from fine particles abraded off the mass, or from the outer portion having been pulverised, and disintegrated from its contact with the water into which the rocks were protruded, while subsequently they were re-arranged or stratified.*

Nodular, or *spheroidal hornblende-rock*, is made up of blocks, or irregular spheroids, from the size of a man's fist to five or six feet in diameter, irregularly heaped together, the interstices being filled with a schistose substance, which is sometimes more or less curved round the blocks, or with a felsitic-schistose rock, or even with quartzitic stuff, or a mixture of their substances. A very peculiar variety of this rock, only observed in one or two places, had a felsitic-schistose matrix, very like felspathic-dioryte, except that it is foliated, in which the blocks of hornblende-rock were enveloped. This rock merged into the hornblende-rock, but not into the associated gneiss and schist.

Usually, as previously stated, the nodular-hornblende-rock merges into conglomeritic schists or gneiss (*metamorphosed agglomerate*) so gradually, that no boundary can be drawn between the two kinds of rock; for which reason it would appear that this variety is not originally a normal igneous rock, but rather represents the broken up portions of the flows, rounded by abrasions against one another, or by weathering, while the interstices were filled by the abraded and disintegrated portions, sometimes combined with foreign substances. Many lava flows have margins of loose blocks, that are thus described by Smyth:—"Cooling and hardening on the surface, cracking, breaking up, and falling forward in clinkery masses of rattling cinders and stones—such must have been the mode of progression of these black streams, as with many of the Vesuvian lavas under ocular inspection."† And if such had been the margin of the ancient flows in West Galway, we could well imagine that now they graduate into a nodular rock, not a normal igneous rock, or yet a typical tuff. Scrope,‡ however, and others, allude to the spheroidal and concretionary structure of some basalts, and some of these rocks might possibly have so originated.

The nodular hornblende-rocks graduate into the previously described conglomeritic-schist and gneiss.

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* Forbes has microscopically examined one of these schists, and proved that it belonged to the derivate rocks. *Microscope in Geology*, pp. 13 and 15.

† "Teneriffe," by C. Piazzi Smyth, F. R. S., p. 249.

‡ "Volcanos," p. 111, and pp. 184, &c.

Foliated felstone or gneissyte and granitoid felstone.—These rocks may occur cutting across the stratification of the metamorphic sedimentary rock as dykes, or they may be in masses or beds. The most common variety of the foliated-felstone is a gneissoid-rock consisting of layers or leaves of quartz, felspar, or felsite and mica, apparently similar to the rock described by Cotta, and called *gneissyte* or *irruptive gneiss.**

In varieties, amphibole or ripidolite may partially or wholly replace the mica; pyrite also is often present. Some foliated-felstones are schistose; usually the rock consists of layers of felsite and mica, amphibole or ripidolite; there are, however, rocks that are aggregates of quartz and felsite or felspar—the constituents of both the gneissoid and schistose varieties depending altogether on the composition of the original rocks.

The lines of foliation usually are parallel, or nearly so, to the walls of the dyke, but at other times they are oblique or even spheroidal. The most prevalent structures in felstones were enumerated when describing those rocks; and on a comparison of the foliation in gneissyte with the lines of structure in felstones, a remarkable similarity will be found, consequently it does not appear unreasonable to suppose that the foliation in the gneissyte has been induced by the most prominent lines of structure in the original rocks. In places, the foliated rocks can be traced until they graduated into rocks in which foliation has not been developed. Gneissyte was principally noted as dykes among the gneiss and schist, but in the neighbourhood of Barna there is a foliated felstone in the porphyritic-oligoclasic-granite (*Galway-type-granite*). Its occurrence in such a place seems to be remarkable, and hard to explain, nevertheless, the writer of this essay on a former occasion has suggested an explanation for the phenomena.†

Others of the metamorphosed felstones are devoid of foliation. These, may be called *granitoid-felstone* from their appearance.‡ They are a granular compound of felsite and quartz; or of felsite, quartz, and mica; or of felsite, quartz, mica and felspar, and from the latter the rock graduates into a granite. In a few localities amphibole, or a mineral that appeared to be ripidolite, was noted in addition to the mica. In more than one place these rocks can be traced until they graduate into a felstone, very little if at all altered. Most of these rocks seem to have been originally highly-siliceous-felstones (*petro silex*); therefore, they for the most part have orthoclase for their felspar; there are, however, other granitoid-felstones that appear originally to have been basic-felstones (*euryte*), and these were changed into rocks in which oligoclase, amphibole, and such like minerals are essentials.

* Cotta, l. c., p. 234.

† Journal of the Roy. Geol. Soc., Ireland, 1871, vol. iii., p. 1. They may, however, be foliated normal felstones, as normal foliated intrusive granites (as at Newry, Co. Down) occur in places.

‡ Macculloch describes rocks among his granites that evidently are similar to these rocks.

The gneissyte and granitoid-felstone that occur in bedded masses are more or less hard to determine, as some, especially among the gneiss, are very similar to many of the metamorphosed sandstones and grits. They, however, generally weather with a white crust somewhat like a felstone, which weathering among the metamorphosed sedimentary rocks is unusual only on felsitytes and felsitic-quartzytes. Moreover, in some cases a rock that apparently is bedded, when carefully traced will be found to cross or intrude into some of the associated bedded rocks.

Granitic Rocks.—The granitic rocks may be highly siliceous, or more or less basic; both of these groups contain rocks that are intrusive, the latter others that have been formed *in situ* by extreme metamorphic action. Previous to entering into the description of the typical granites, the *elvanytes* or *quartz-porphyrites* should be enumerated and described, as they are the granitic-rocks next in order to the plutonic-rocks.

Elvanyte or quartz porphyry.—These passage-rocks between the plutonic-rocks and the typical granites are always more or less granitoid. They seem to belong to the granitic-rocks, as they are hypogene, and consequently never are associated with tuff or any other such mechanically formed accompaniment. Nevertheless, in part they are allied to the plutonic-rocks as they graduate into them; moreover, at the extreme margin of wide dykes, also in small dykes, branching from a large one, a rock often occurs that in aspect is undistinguishable from a plutonic-rock. These compact portions at the walls of dykes are never more than a few inches in thickness.*

Elvanytes range from highly siliceous to basic,† according as they are the passage-rocks from felstone or whinstone to granite.

Elvanyte has a more or less crystalline felsitic or felspathic base, usually with globules, bleds, or crystals of quartz, crystals of felspar, and flakes of mica or ripidolite or crystals of amphibole; pyrite also is often present, beside other minerals, generally as accessories, but sometimes locally as essentials. In all elvanytes some of the quartz seems to have crystallized out first, but sometimes only sparingly. In the highly siliceous varieties this quartz is characteristic of the rocks, while in the more basic varieties it is often scarcely perceptible. Scheerer excludes from his true granites rocks in which part of the quartz crystallized out before the other constituents, as will be seen from the following epitome of this eminent geologist's definition for granite:—"The crystals of felspar, and others not containing water, crystallized out first; the mica, which con-

* The compact portion is called by Cotta *the base* or *mother-rock.* Rock classification, l. c., p. 214.

† There are granitoid-basic-rocks very similar in appearance to some of the previously mentioned varieties of hornblende-rock; some of these probably belong to this group; however, in the country to which this essay refers this could not be proved. There are, however, as will be hereafter stated, rocks that might be called syenyte, which belong to this group.

tains much water, probably next; and the silex, which the heated water would longest hold in solution, last." Nevertheless, this opinion does not seem to be universal, as Cotta and others place such rocks as elvanyte among the granitic-rocks.*

The base may be green, grey, purple, brown, blue, or even yellowish; the latter colour, however, seems generally, if not always, to be due to weathering. The base usually gives the colour to the rock, but it may be more or less modified by the colour of some of the contained minerals. All the highly siliceous varieties, and some of the basic, weather with a more or less smooth, flowery outline, so characteristic of the felstones, and not with the rugged, rough aspect of a granite; some amphibolic or pyroxenic varieties, however, weather rough. The quartz bleds, globules, or crystals, scattered through the mass, range from mere specks to the size of peas, or even larger, in some of the highly siliceous varieties being so numerous as to give the rock a pisolitic appearance. They internally have a glassy appearance and fracture; on some of the blebs the crystal faces can be recognised, while others appear to be minute coated balls. The latter often have a radiated structure, and in some there is a minute hollow in the centre.†

The varieties in composition of the elvanytes that were observed in this country are highly-siliceous (*quartzitic-elvanyte*), having numerous orthoclase crystals (*orthoclasic-elvanyte*), or, perhaps, oligoclase crystals (*oligoclasic-elvanyte*); mica in some may be so abundant as to give a character to the rock (*micaceous-elvanyte*), or that mineral may be wholly or partially replaced by amphibole or ripidolite (*hornblendic-elvanyte* and *chloritic-elvanyte*).‡ The highly-siliceous elvanytes have orthoclase for their felspar. The basic elvanytes usually have a trialinic felspar or the lime orthoclase (adularia), with which are associated such basic minerals as amphibole, pyroxene, and the like.

In some of the elvanytes in the neighbourhood of Galway, and also in the island of Lettermullan, many of the orthoclase crystals (flesh-colour) are enclosed in an envelope of light green felspar (oligoclase?), somewhat similar to the Finland rock that has been called Rapakivi granite (*Rapakivi-elvanyte*).

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* Jukes classed in his elvanytes the rocks called by Cotta "granitic-porphyry" and "quartz-porphyry." In the latter group Cotta, as well as Jukes, seems to include some rocks that evidently are quartzitic-felstones; but as such are not hypogene-rocks, they do not properly belong to this group.

† The latter can be seen with a pocket-lens. I have tried to get a section of one to examine under the microscope, but as yet have not succeeded, as out of numerous slices of elvanyte none contained this peculiar form of the quartz.—[*Note in press.*]

‡ Micaceous-elvanyte would be called by some geologists *mica-trap*; this further shows that the term is not a class-name. Hornblendic-elvanyte would, by some, be called *syenyte*; this, for those in which the felspar is only orthoclase, is correct; in many of them, however, orthoclase is not the felspar, consequently, for such rocks the name would be incorrect.

In structure elvanytes vary; some are finely crystalline, so as to be nearly compact, while others are granular or granitoid, the latter graduating into typical granite. Elvanyte graduating into granite is well exemplified in the neighbourhood of Kylemore. Here, south and south-west of Bengooria or Diamond Hill, are protrusions, in part scarcely distinguishable from typical granite, nevertheless, in all of it blebs or crystals of quartz that were developed before the other rock constituents can be detected, more or less, while toward the margins of the masses the rock is a typical *granitoid-elvanyte*. Moreover, from the tracts extend numerous dykes, some being large and others small; all the former are more or less granitoid, while the latter are finely crystalline or nearly compact, some apparently merging into quartzitic-felstone. Part of the rock in mass, although granitoid, has the typical weathering of elvanyte, which seems due to all the quartz and felspar not being crystallized out, parts of these remaining undeveloped; and from this peculiar weathering the Cornish name seems to be derived (el, oil rock, ban or van white), as the white smooth crust has a marked contrast when compared with the rough weathering of granite.

Some rocks like elvanyte are gneissoid. This structure may possibly be due to metamorphism; as in the neighbourhood of Galway, in one or two instances it has been proved that some of the elvanyte is older than some of the typical granite, but as a general rule the elvanytes are newer; and in the country north of Killary Harbour, where the rocks are only slightly altered, there are large dykes of foliated elvanyte; moreover, they were only observed in the neighbourhood of protrusions of granite, and may possibly be connected with them.*

My friend and colleague, R. G. Symes, F. R. G. S. I., &c., seems to have been one of the first who pointed out the graduation of granite through elvanyte into felstone. While examining the rocks adjoining the north shore of Galway bay, I suspected such must be the case, and mentioned my opinion in the Geological Survey Memoirs. Since then I have seen the gradation in various localities.

Granite.—Of typical granite the principal varieties in composition will be found in the following list. There are others, some being very remarkable, not only in composition, but also in structure; however, they are only varieties of the rocks enumerated.

Typical Granites.

Basic oligoclasic-granite	Metamorphic (Galway-type-granite). Intrusive Omey-type-granite).
Highly siliceous ortholasic-granite.	Metamorphic. Intrusive (Oughterard-type-granite).

* The country between these dykes and the granitic masses is covered with drift. It appears remarkable that these foliated rocks should only have been found hereabout associated with other granitic dykes. This foliation can scarcely be due to metamorphism, on account of the unaltered condition of the associated rocks.

Haughton divides the granites of Ireland into three groups, viz.:— I. *The granites of Leinster;* II. *The granites of Mourne and Carlingford;* and III. *The granites of Donegal, Mayo, and Galway.* These belong to two classes, first, *intrusive*, containing the first and second groups; and second, *non-intrusive*, containing the third group.*

Mr. Deleese "also distinguishes two kinds of granite, one irruptive and the other metamorphic; the latter taking often a gneissoid structure."†

Haughton's first group seems to be nearly identical with the orthoclasic intrusive-granite, while the oligoclasic metamorphic-granite represents his third group.

Metamorphic oligoclasic-granite (Galway-type-granite).—These are of metamorphic origin or *formed in situ;* that is, the granite is due to the extreme metamorphism of derivate and igneous rocks in the placé, in relation to the associated rocks that it now occupies, and was not intruded or thrust up into its present position.

This rock, the "Galway-type-granite" of the Memoirs of the Geological Survey, is a crystalline porphyritic aggregate, having as conspicuous essentials pink or flesh-colour felspar (*orthoclase*), greenish or yellowish waxy felspar, white felspar,‡ quartz, black mica (*lepidomelane?*), white mica (*muscovite?*), and pyrite or marcasite. The common accessories are amphibole, titanite, ripidolite, epidote, chalcopyrite, galenite, flourite, talc, and garnet. The first three of these accessories seem locally to be also essentials. Thus in the *Furbogh-type-granite* (called after Furbogh, six miles west of Galway, where this variety is the prevailing rock), amphibole and titanite are essentials; in other localities amphibole and ripidolite, also epidote, are not uncommon: the latter, however, is believed to be due to decomposition. Pyrite is mentioned among the essential, as it seems never, or on very rare occasions, absent.

The orthoclase usually occurs in large crystals, often twins, some being over two inches in length; they usually give the porphyritic character to the rock; however, in a few places, the white felspar may do so. In one locality (*Furbogh*) some of the large flesh-colour crystals (*orthoclase*) are enclosed in a white felspar envelope. The amphibole in places is accompanied by titanic, or ripidolite, or by a green epidotic-looking mineral, the *hornblendic-granite* occurring as irregular subordinate masses—the variations in the composition of metamorphic granite, as pointed out by Haughton, being due to the different rocks from which it was formed. In places, there are irregular and vagrant patches, and veins of a variety, "very coarsely

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* For a resume of Doctor Haughton's conclusions on the granites of Ireland, see W. W. Smyth's, F. R. S., &c., Presidential Address to the Geol. Soc. Lond., Quar. Jour., vol. xxiv., p. lxxiv.

† Volcanos, by G. P. Scrope, F. R. S., &c., second ed., 1862, p. 300, *foot-note.*

‡ Some of the waxy felspar is triclinic, but usually it is more or less amalgamated with a variety of orthoclase, probably adularia; the white felspar also is probably adularia.—[*Note added in the press.*]

and irregularly constituted, of orthoclase, quartz, and silvery white mica," answering Cotta's description for the rock he calls *pegmatyte.**

In some places the crystal of felspar are very large, they being two inches or more long. This class of rock† in places may have been formed subsequent to the associated granite; in others it has not, as will hereafter be pointed out.

Veins of segregation (*Granityte*), always fine, are not uncommon, and two or more systems may occur together, their different ages being known by their entering and displacing each other.

These are more or less regular, generally having an angular arrangement, apparently occupying lines of joints, and they seem to be due to matter which has segregated from the liquid or semi-liquid portions near the interior of the mass having been pressed up into the shrinkage fissure formed in the consolidated portion, as the latter cooled, each successive system of cracks having their own veins.

When looking over an explance of the Galway-type-granite, it is not unusual to find the large crystal of felspar lying in irregular parallel lines, while towards the noith-east and north margin of the great tract that bounds Galway Bay on the north, the rock is found gradually to become more and more foliated (*gneissoid granite* or *granitoid gneiss*), until eventually it graduates through gneiss into schist (see Section, Figure S, Pl. 12). Towards the south, however, in the vicinity of Galway Bay, another change takes place, as here the rock graduates into a more or less even-grained granite, in which, as a rule, none of the felspar is porphyritically developed. This even-grained granite seems to extend as courses into the porphyritic granite, while associated in places are many elvanytes. It may be here remarked that, in the immediate neighbourhood of Galway, there are many elvanytes, as a rule, in large dykes, that are associated with courses or dykes of granite, all usually running with a general north and south bearing.

The conspicuous essentials of the even-grained granite are in general very similar to those in the porphyritic variety, but not always; as in places, courses of this granite vary not only in texture and structure, but apparently also in composition: and what may perhaps be more important, in one place, where gneiss overlies these granites, the dip and strike of the courses seems to be similar to the dip and strike of the stratification of the gneiss. In the neighbourhood of Furbogh were observed patches of a very hornblendic and titanitic granite, in which there is none of the flesh-coloured orthoclase, or white mica, and only a little black mica. Toward the west and north-west, the Galway-type-granite graduates into the Omey-type-granite.

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* Cotta, l. c., p. 206.

† These veins probably belong to the class called Endogenous by Hunt. See p. 131.

To the north and north-east, the gneissoid-granite seems to have similar constituents to the typical rock; but the mica and quartz, with part of the felspar, are arranged in leaves or plates, while the large crystals of felspar are generally arranged rudely parallel to the layers, but not always, as they often cut across them; schistoid-beds also occur in it. The foliation, irrespective of the dip of the original rocks, is perpendicular, or nearly so; but the strike seems always to correspond with that of the stratification of the associated gneiss. However, as the rock loses its granitic character, and becomes more and more gneissose, the original dip of the rocks becomes apparent.

Among the metamorphic derivate rocks of the barony of Ballynahinch or Connemara, there are large and small tracts of granitoid-gneiss, the rock being identical with the gneissoid-granite, forming the north and north-east limits of the great tract of Galway-type-granite. These tracts always occur in, and naturally might be considered a portion of, the *gneiss-series;* nevertheless, in some places the rock loses all traces of foliation, and becomes a granite undistinguishble from the Galway-type-rock, the essentials, accessories, structure, and aspect being identical.

That these tracts of granitoid-gneiss, or gneissoid-granite, are highly metamorphosed parts of the *gneiss-series*, and not accidental intrusions of granite, to me seems proved, as the one rock not only graduates into the other, but also in places schistoid layers will traverse the granitic rock, these layers having a strike and dip agreeing with those of the stratification of the associated gneiss and schist. Such changes in isolated portions seem due to portions of the derivate rocks, on account of the materials composing them being more easily changed than the associated strata. This is very conspicuous at Forlorne Point, Co. Wexford, where beds of granite are found associated and interstratified with beds of incipient micasyte, hornblendyte and talcyte.

The change from gneiss into granite is most remarkable in the conglomeritic and nodular rocks. As previously pointed out, all former structure, except the strike of the stratification, is generally obliterated in the granitoid-gneiss, the only exception apparently being, that some of the blocks in conglomeritic gneiss, more or less modified, may still appear. This, however, is not generally the case, for, as the rocks become more and more gneissic, the blocks usually become elongated, with the foliation curling more or less round them, but subsequently the foliation becomes parallel in lines, the matrix having a fine texture, while that of the blocks is coarse (Fig. O, Pl. 10); the boundary between each being still apparent; and as the change progresses, all seem to differ very little in texture, or rather one merges so gradually into the other, that there is no difference discernible, till eventually all, or all conspicuous foliation, disappears, and the rock becomes a typical granite.

Associated with the tracts of hornblende-rock (*metamorphosed whinstone and euryte*) are smaller or larger masses of granite, similar to the

Galway-type-granite. In some places it is possible, although not very probable, that outburst of granite may have occurred in these places; this, however, appears rarely, if ever, to have happened, as in all cases one kind of rock seems to graduate into the other. This granite has the same essentials and accessories as the Galway-type-granite, is similar in texture to the coarse varieties, and to me it appears probable that similarly, as the sedimentary rock, change into granite, so may also the whinstones and eurytes. If such may happen, these masses of oligoclasic-granite may only be extremely metamorphosed portions of the original outbursts of plutonic rock.

Intrusive-oligoclasic-granite (Omey-type-granite).—Although some of the oligoclasic-granite may have been formed *in situ*, part is undoubtedly intrusive, such as the masses at Omey, Roundstone, &c., which appear as protrusious. To the large tract near Galway, and also to the small tracts since mentioned, there are regular boundaries, while to these protrusions the boundaries are more or less irregular; besides, instead of the granite graduating into gneiss, it may be associated with either gneiss or schist, breaking up through them; consequently the metamorphic sedimentary rocks may dip at or oblique to it, but can never lie conformably on it. Moreover, it sends veins into those rocks, proving that this variety must be a true intrusive rock.

In some places this oligoclasic-granite is in juxtaposition with the gneiss and schist, but in many cases, more especially if the boundary is very irregular, veins and masses of the orthoclasic, or highly-siliceous-granite, intervene. In such cases the adjoining gneiss and schist are usually cut up, displaced, and traversed in all directions by regular and irregular veins of the latter granite, from mere strings to yards in width, sometimes forming such a close irregular network that it is impossible to draw an exact boundary between the granites and the metamorphosed sedimentary rocks.

The intrusive-oligoclasic-granite is very similar in aspect and composition to the oligoclasic-granite of metamorphic origin; nevertheless, after the rocks are studied and known, certain peculiarities will be learned, that are always distinctive marks between the two varieties.

Oligoclasic-granite. (Metamorphic.)	*Oligoclasic-granite.* (Intrusive.)
Amphibole, titanite, and such like minerals, are locally essentials, while often they are accessories.	Amphibole, titanite, and such like minerals, seem ever to be essentials, and sometimes are not accessories.
Gneissoid, or schistoid layers or courses, sometimes occur in the mass of the rock, while lentels and irregular patches are not uncommon.	Gneissoid, or schistoid layers or courses, never occur, while lentels and irregular patches are rare.

The granite graduates through gneiss into schist.	The granite never graduates into gneiss or schist.
A foliation more or less conspicuous is often present, or, if it is absent, the large crystals of felspar are often arranged in lines, not perhaps visible in small pieces, but often very conspicuous when the rock is viewed in mass.	No foliation.*
Nearly always porphyritic and coarsely crystalline. The felspar that is usually conspicuously developed being the pinkish or flesh-colour, rarely the white.	Often more or less evenly crystalline, none of the felspars being conspicuously developed. When porphyritic, the white felspar (adularia) often gives the character, and sometimes the green.
Never graduate into elvanyte.	May graduate into elvanyte, and through elvanyte into felstone (euryte), or perhaps even whinstone.

Metamorphic-orthoclasic, or highly-siliceous-granite.—The rocks belonging to this group may occur as masses, dykes, or beds, according to the position the plutonic rocks, from which they were altered, occupied. Usually they are of a fine even texture, and in some it is probable all the felspar and quartz have not crystallized out from the original felsitic mass, such a rock being the passage-rock into granitoid-felstone. These rocks, when weathered, have not the well-marked, rough, rugged aspect of a typical granite, nor yet the smooth weathering of a felstone, but rather a mixture of both, like the weathering of a felspathic sandstone. When typical, the principal minerals they consist of are quartz, orthoclase, and mica, pyrite also being usually present; such rock being metamorphic-petrosilex, or orthoclase-felstone. From being highly-siliceous they may graduate into a metamorphic-oligoclasic-granite, or a hornblendic-granite, following the different gradations of the plutonic rocks, from which they originated. In rocks of this group it is not unusual to find lines, or a riban, having an aspect somewhat like stratification due to bands of different colour, texture, and perhaps also composition. The bands, or layers, may be coarser or finer than the rest of the rock, or they may be more micaceous, quartzitic, or felsitic, or they may contain minerals, not essentials otherwise, of the rock. They are probably due to a structure in the original rock, perhaps the lines of viscid-fusion, or

* In this area there seems to be no foliation, or trace of foliation, nevertheless in certain oligoclasic granites, north-east of Castlebar, county Mayo, and apparently belonging to this variety (as they occur in dykes and large sewers), there is a distinct foliation. As I never carefully examined these Castlebar rocks I cannot give particulars about them.

such like. In the vicinity of Galway, the late Mr. J. Beete Jukes pointed out that, in some wide courses or dykes, the outside portions were granitic rocks, while the interior was a felstone, seemingly proving that the change must be due to metamorphic action.

This variety of granite often is found associated with felsitic-quartzyte and quartzitic-felsityte, and often appears to graduate into the former. For which reasons it seems probable that some at least of those rocks originally were either felstone or felsitic-tuffs.*

Mac Culloch seems to have classed together this granite and granitoid-felstone as different varieties of one kind of rock.† Of the latter, he says, "This variety is never perfect, as it contains the same minerals" [quartz, felspar, and mica], "without form;" while in his first division of the granite, he includes a rock, the description of which would answer for felsitic-quartzyte or quartzitic-granitoid-felstone.‡

Intrusive-orthoclasic, or highly-siliceous-granite (*Oughterard-type-granite*).—This rock only occurs as intrusive masses, dykes or pipes. Jukes pointed out that, in West Galway, when in mass, it always occupied low ground, while in the adjoining high ground, when it appeared, it was as dykes, pipes, or small protrusions. This peculiarity he had also observed in Newfoundland, and other places, from which he concluded that, being a deep-seated rock, it was exposed only in low ground, when the superior rocks had been denuded away; it, however, also extended under the adjoining high ground, as was proved by the dykes or off-shoots from it, but was still unexposed, denudations having failed to remove the covering rocks. According to this view, the deeper and more extensive the denudation, so much larger ought the tract of this orthoclasic-granite to be.

The rock, as just stated, has two characters—one massive, and the other a vein-rock, and, when found in these different positions, its composition seems to vary. Under all conditions the rock appears never to contain oligoclase as an essential, and when in veins or pipes it appears usually to be a crystalline aggregate of orthoclase, quartz, and a greenish mineral, which is probably an earthy mica, or perhaps ripidolite, with more or less pyrite or marcasite. The greenish mineral in places is undoubtedly a mica; but in other places it has very much the aspect of ripidolite, and possibly both minerals may be present. When in tracts, and wide veins or courses, the conspicuous constituents seem to be orthoclase, quartz, black mica, white or green mica, and pyrite or marcasite, while the principal accessories are ripidolite, galenite, chalcopyrite, barite, calcite, flourite, molybdenite, &c. These often occur in nodules, lentils, and geodes, with lenticular

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* It was previously mentioned that some of the rocks classed as felsitic-quartzyte originally may not have been sedimentary rocks.

† Mac Culloch, pp. 235 and 237. Granite. Second division. A. a. and A. d.

‡ Id., p. 234. B. a.

patches of a green mineral, called by the miners *peach*;* also with drusy cavities, or small vugs, lined with crystals of quartz.

The rocks in the veins may vary. In some places, so siliceous as to look like quartzyte, and in a few it is a finely crystalline white rock, in which the quartz and mica are so minute that they can scarcely be detected by the naked eye. In a dyke on Shaunaunnafeola, the centre is a finely crystalline aggregate of quartz, orthoclase and black mica, while the outside portions near the walls are coarsely crystalline compound of quartz, orthoclase, white mica, and pyrite, the latter constituent being conspicuously abundant. This vein was in a neighbourhood where there are granites that are evidently metamorphosed felstones, and possibly it may also belong to that class. In a few veins, part of the mica, white probably muscovite, has a plumose arrangement, as if plumes of feathers were pasted down on surfaces of the rock. The surfaces in those places where this arrangement was noted were parallel, or nearly so, to the walls of the veins. This variety appears to be similar to the rock described by Jukes, and called *plumose-granite*.

North-east of Recess, in the townland of Derrynea, there is a vein, having in the centre a coarsely crystalline rock, while towards the walls the rock is of a fine texture. In the hill called Lisoughter, and also in other places in the barony of Ballynahinch, peculiar veins were observed, being very coarsely crystalline, the quartz and the felspar occurring in masses often the size of a man's fist, while the mica is proportionally large. In these rocks usually the mica is of a silvery palish olive-green or a whitish colour, but black mica may also occur in small flakes. The large mica is sometimes most peculiarly arranged, so that on weathered surfaces the edges of the flakes have angular forms, as if the rock was inscribed with some kinds of written characters. In other veins, that appear allied to those last described, and always when they traverse or are in juxtaposition with limestone, patches may lose all their mica, while the quartz and felspar are arranged like Hebrew characters, answering the description of the rock that has been called *graphic granite*.† The granite veins last described are evidently different to the first, and seem to be newer than them. Possibly they may belong to the class called *endogenous* by Hunt, while the others belong to his *exotic rocks*.‡

The granite in mass may also have varieties. In some places it

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* The true *blue peach* of the miner is ripidolite, and the mineral in these nests is very like it in aspect and feel, but it has not been analysed.

† Hunt mentioned veins of graphic granite associated with limestone among the American rocks. (*American Journal of Science and Arts*, Third Series, vol. i., No. 3, p. 183).

‡ These veins I believe not to be true granite dykes, but rather to belong to the class called "granitic-veinstone" by Hunt. I, however, here describe them, as other authorities class them with the true granites. The vein rock just described in Derrynea may also belong to Hunt's "endogenous rocks."—Report Geol. Survey, Canada, 1865, p. 192.

appears to lose all its quartz and mica, and to merge into a crystalline felspathic mass (*felsitic granite*).* The aspect of this rock is well described by Cotta—"a rock of compact texture, about the hardness of felspar, with dull or smooth conchoidal or fissile structure; colour, yellowish, reddish, grey, greenish, or bluish, weathering white." The loss of the quartz and mica is, however, more apparent than real, for on a close examination with a lens both may be detected, always very minutely and often sparingly developed. In another variety the rock appears to lose its felspar and to become a crystalline granular compound nearly solely of quartz and mica (*quartzitic granite*).† This rock undoubtedly is very quartzose, and perhaps, although closely allied to them, ought to be excluded from the true granites; for although in general a little felspar can be detected, that mineral often appears to be absent, and when present, presents more the appearance of an accessory than an essential. In some places even the mica also is unapparent, the rock being very similar to the rocks at Bray Head, Co. Wicklow, and called *quartz-rock* by Jukes. These quartzose-rocks are peculiar, and hard to explain. At Curraun, immediately south of Maam Bay, the N. W. arm of Lough Corrib, and in other places, the quartzose rock undoubtedly graduates into the intrusive highly-siliceous or orthoclasic granite, but in some places the relations between the quartzose-rocks and those associated with it are very obscure. At Canrower and Croaghnacloosh, both in the vicinity of Oughterard, masses of this rock occur, seemingly in connection with the Oughterard-type-granite, but the coat of bog that covers so much of that country prevents them from being properly examined. In both of these places the quartzose-rock is foliated, and apparently identical with quartzyte that in other parts of this country is undoubtedly metamorphosed sedimentary rock. However, in these two places the quartzose rock quite disagrees, as to strike and dip, with all the schists and gneiss in its vicinity, and as the exposures are in irregular patches, they scarcely could have been brought into their present positions by faults.‡

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* Felsite-rock of Cotta, p. 220.

† Seemingly the rock called greisen by Cotta, pp. 207 and 321.

‡ All the details in relation to these exposures of quartzose-rock are given in the Geological Survey Memoir, ex-sheet 105, pp. 33, 39, to which the reader may be referred.

PART II.

Suggestions to account for the Origin of the Granitic and other Hypogene Rocks.

In the preceding part of this essay it was demonstrated that the whinstones may graduate through euryte into felsyte (*petro-silex* or highly siliceous felstone), while these plutonic rocks (whinstones and felstones) graduate into the granitic rock and through elvanyte into typical granite; the granitic rocks being of different types, some being more basic than others; and as there are basic and highly siliceous plutonic rocks, so also in the granitic rocks some elvanytes and granites are basic, while others are highly siliceous. It has also been shown that all normal rocks, whether derivate or igneous, may be metamorphosed; at first becoming schistose, second gneissic, and finally granitic, the granites varying in accordance with the nature of the constituents composing the rocks previous to their being metamorphosed.

Before proceeding further, and for the convenience of reference hereafter, the ingenite rocks in this area may be divided into seven groups, namely, I., *the schist-series;* II., *the gneiss-series;* III., *the non-intrusive-oligoclasic granite;* IV., *the intrusive-oligoclasic granite;* V., *the orthoclasic granite;* VI., *the elvanyte;* VII., *the plutonic rocks**.

It seems to be now generally allowed, that all granitic and other ingenite rocks were formed from previously-existing rocks, the hypogene at a depth beneath the earth's surface, but the volcanic and plutonic rocks at or close to the present or a former surface of the globe.

Some of the hypogene rocks (*granitic rocks*) must at one time have been more or less fused and liquified, while others (*gneiss and schist*) were never fused or liquefied, but were more or less changed by heat, either wet or dry. Wet heat, judging from the rocks of West Galway and Mayo, would seem to be the more probable; for in all the schist, gneiss, and non-intrusive granite, the original joint-lines, as previously mentioned, are either sealed, or a thin portion of the rock adjoining the joint walls is silicefied and indurated, as if by being percolated by steam charged with silex or some such substance (figs. G. H. Pl. 9 and P. Pl. 10).

If we suppose that at a certain distance beneath the surface of the earth all rock becomes fused and liquefied, the rocks in the zone above the melting point would be fully mineralized, but not liquefied, while

* In this table the metamorphosed plutonic rocks might be ignored, as they do not affect the following arguments—nevertheless, all of them, excepting the metamorphic orthoclasic granite, are included in the above classification. The hypogene rocks, as the name implies, were formed at a depth beneath the surface of the earth, and under a pressure more or less great; the granitic rocks having been fused and subsequently cooled, and consolidated, prior to their being exposed by denudation at the present surface of the earth.

each successive stratum would in general be less and less affected;* and if the rocks while in these conditions began to be raised, or in any other way removed out of the influence of the heat, apparently there would be conditions to account for the formation of all kinds of ingenite rocks.†

The stratum that included all the rocks which were altered, but not fused, would contain the metamorphosed rock; the upper portion of the rocks belonging to the *schist-series*, and the lower part to the *gneiss-series*. Below this stratum, in the zone where the rocks were fully mineralized, but not liquefied, there would be a *non-intrusive* granite rock formed, which would remain in its original position as regards the overlying rocks, but its nature and constituents would be quite changed. Below the melting point would be a mass of fluid, from which all the intrusive rocks would come. Furthermore, rocks formed under such conditions would, as in nature, have no hard lines of demarcation, the lowest members of each graduating into the upper portion of the group next below it.

The formation of the non-intrusive groups of hypogene rock has been suggested, but there still remain the intrusive rocks to be accounted for. As the heat became less, the liquified portion would cool and consolidate under various conditions, consequently forming rocks not only different in aspect, but also in composition. At the first, two magmas would form—a basic above, and a highly siliceous below. As the superincumbent rocks cooled, cracks and other fissures should form, into which portions of these magmas ought to be forced by the pressure of the overlying mass, and also by the escape of pent-up gases and steam. These intrusions, according to the magma from which they came, ought to be basic or highly siliceous, and, if forced to the earth's surface, they would cool and consolidate, under little or no pressure, forming the different varieties of *plutonic* and *volcanic rocks*, while the portions that solidified between their source and the earth's surface would become *elvanyte*, a granite and hypogene rock, but not a typical granite, as some of the silex crystallizes out before the other rock constituents.

There now only remains the intrusive granites to be formed from the residue of the fluid magmas, and the conditions under which these would cool have to be considered. The more acid magma should cool slower than the basic; therefore, there ought to be two distinct rocks forming the magma; that cooled first becoming a basic rock (*oligoclasic granite*), while the other, that took longest to cool, would form the *orthoclasic*, or *highly-siliceous granite*.

* In some rare instances, as previously mentioned, beds or portions of beds might be changed into granite while the associated rocks above, below, and around were only changed into gneiss or even schist.

† Since this essay was read, Professor le Conte has published a most instructive paper on the "Features of the Earth's Surface" (American Journal of Science and Art, third series, vol. iv.), which bears on this subject, and to which the reader is referred. [*Note in press.*]

Either of these kinds of granite would, at any time prior to their final solidification, be liable to form intrusive masses or veins, being forced up into fissures, cracks, or any other kind of "shrinkage fissure," or vacancy formed during the cooling of the overlying rocks, the resulting rocks being respectively oligoclasic or orthoclasic granite, according to the magma from whence they came. Furthermore, after the mass of either the oligoclasic or orthoclasic granite had cooled, there would still be centres containing unsolidified portions, that at any time would be liable to be forced up into the shrinkage fissures as the mass cooled. The veins, *Granityte*, thus formed would necessarily be more siliceous than the associated rock-mass; but in the oligoclasic granite, although different from the associated rock, they might be nearly similar, and scarcely distinguishable from the orthoclasic granite; however, such veins in the orthoclasic granite would be quite distinct, being more siliceous than the mass. In this way a solution for the formation of the quartzitic granite might be suggested; for, if we could imagine a fluid centre becoming more and more siliceous as zone after zone cooled, the residue finally might be so siliceous as to be similar, or nearly similar, in composition to quartzyte.

If the granitic and other ingenite rocks were formed under circumstances similar to those above suggested, all the relations between the different rocks could be easily explained. In West Galway, and South-west Mayo, these all graduate through other rocks into each individual rock, yet none of them pass suddenly into a different class rock—each must graduate through the intervening passage-rocks. A schist must graduate through a gneiss into a non-intrusive oligoclasic granite; a gneiss through a non-intrusive oligoclasic granite into an intrusive oligoclasic granite—a non-intrusive oligoclasic granite through an intrusive oligoclasic granite into an intrusive orthoclasic granite, and the latter rock through an elvanyte into a plutonic rock, while among the latter class of rocks a petrosilex must graduate through an euryte into a whinstone; all the other graduations are similar, therefore, it appears unnecessary to enumerate them, and such changes are all accounted for by the above suggestions.* The *volcanic* and *plutonic* rocks would have to range from basic to highly-siliceous, according to the zone and time from and at which they were intruded; so would the *elvanytes*, and so would the *intrusive granites*. The granite formed *in situ* would be very varied in its composition, on account of the various rocks from which it originated; yet it would graduate into intrusive granite, and so form one of the connecting links between the plutonic and the metamorphic sedimentary rocks.

The plutonic and volcanic rocks, being surface-formed, should only be found among surface-rocks; but as all may at some time or other be at the surface of the earth, they are found breaking up through all

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* In another place a list is given of the changes remarked in the rocks of this country.—Journal Roy. Geol. Soc. Ireland, vol. iii., 1871, p. 8.

varieties, but only interstratified with those that are surface-formed. Elvanyte, on the other hand, is a hypogene rock, and, as its natural place is near the granite, it should more frequently occur among the metamorphic rocks. This seems to be the case; for, years ago, while reading different accounts of tracks of metamorphic rocks, but especially Logan's reports on those of Canada, I was struck with the frequent occurrence of elvanyte among them. They do, however, range into other strata. In Yar-Connaught, although they all occur associated with the metamorphic rocks, yet many of them apparently have no connection with that group, or the Galway type granite, as for instance those previously mentioned as occurring in the vicinity of Kylemore, south and south-west of Bengooria, also many in the country to the eastward of Clifden. These may be of Silurian age, as they graduate into eurytes identical with the eurytes interstratified with the rocks of Upper Llandovery age. If this surmise is correct, we have data on which to calculate the depth beneath the earth's surface at which a felstone or other plutonic rock will graduate into an elvanyte. The mass of euryte at Benchoona is about 2000 feet above the base of the Silurian rocks; but if we suppose a thickness of the metamorphic rocks equal to half of this was denuded away in the neighbourhood of Ballynahinch lake and Clifden, where these rocks are so numerous, these would be a total thickness of 3000 feet. There is, however, another locality in Ireland, namely, the county Limerick, where an estimate also can be made. In that county there are bedded dolerytes, melaphyres and eurytes in the carboniferous rocks, at the junction of the lower and middle limestone, and at the junction of the limestone and the coal measures; while in lower rocks, near the base of the carboniferous limestone, are pipes or protrusions of basic elvanyte, evidently the roots of some of the rocks that at higher zones were irrupted among and bedded with the derivated rocks. Between the rocks where these roots occur and the junction of the lower and middle limestone there is a thickness of about 1000 feet, and to the base of the coal measure of about 2300 feet. If, therefore, these roots belong to the igneous rocks of the lower zone, elvanyte may form at a depth of about 1000 feet, while if to the upper, at a depth of 2300 feet.

It was previously stated, that between the intrusive oligoclasic granite and the metamorphic sedimentary rocks intrusions of the orthoclasic granite were not uncommon. This, if the above suggestions are correct, might naturally be looked for. For as the mass of the oligoclasic-granite cooled, it would shrink from the adjoining rocks, thereby causing vacancies into which the non-consolidated orthoclasic granite should be intruded, and also into all the cracks and fissures in the associated gneiss and schist formed during their cooling, they necessarily having been heated and expanded while in contact with the oligoclasic granite.

It seems to be a very generally-received opinion that all granites metamorphosed the rocks with which they come in contact; to me, however, it appears that granite is the result of metamorphism, and not metamorphism of granite, and that the rocks associated with granite formed *in situ* must be metamorphosed; but that rocks, even in contact with intrusive granite, may only be slightly altered, not more so than often happens to rocks in contact with large dykes or masses of plutonic rocks.*

In the islands north of the mouth of Galway Bay (Gorumna and Lettermullan), the rocks are very little altered, yet they are adjoining or in close proximity to a large tract of intrusive granite. North of Killary Harbour, the rocks forming the hills north of Doolough are scarcely changed, so that if met with in any other locality the alteration would be passed over unnoticed; yet immediately to the north of them is a large tract of intrusive granite, while in the neighbourhood of the Oughterard tract of granite, the sedimentary rocks are less altered than in many other places in West Galway. Here limestone is found in contact with the granite, and often caught up in it, yet the limestone is not much changed; that caught up in it, or in immediate contact, has lost all its colour and become highly crystalline; but these changes only exist for a few yards, as limestone not 200 feet from it was found to be scarcely altered, compared with other places in the district. On the other hand, an observer can always know when he is approaching granite formed *in situ*, by the remarkable changes that take place not only in the aspect, but also in the structure of the rocks.†

* In the country north of Killary Harbour there are shales adjoining dykes of felstone altered into hornstone. At Curraghrevagh, on Lough Corrib, there are silurian rocks micacised and indurated by a protrusion of diabase, and in many other places in Ireland similar alterations could be pointed out; the rocks in each case being more metamorphosed than any of the rocks that I saw associated with, or even in contact with, the Dartmoor granite, Devonshire. From the circumstances associated, when derivate rocks in contact with plutonic rocks are altered, I am inclined to believe such alterations are not due to the plutonic rocks, but to heat, either wet or dry, that came up in the divisional plane or the fissure between the different classes of rocks.

† In some places, as for instance Killiney, the rocks in contact with the mass of intrusive granite of Dublin, Wicklow, Carlow, and Kildare, are much altered; but in other places, such as the neighbourhood of Castledermot, Co. Kildare, they are not. To account for this, I would suggest that some of the intrusive masses of granite cooled under such circumstances that the heat from them had to percolate the associated rocks, while in such masses as that at Dartmoor, Devonshire, where the rocks in contact are scarcely changed, the rock must have cooled under such circumstances that the heat all escaped without affecting the associated rocks. This pent-up heat, if it escaped along the walls of a plutonic or volcanic dyke, would more or less alter the rocks it passed. Every fresh locality for granite that I visit, the more I am convinced that granite is the result, not the cause of metamorphism. Since this essay was read I have more carefully examined the rocks in the vicinity of the granite exposure north of Doolough, county Mayo, and find some of the rocks so little altered that their fossils are quite perfect; while at the extreme S. E. end of the county Wexford there is granite due to metamorphism that graduates through gneiss into schists, while to the N. E. of the same county, and in the county Wicklow, the rocks in juxtaposition with the intrusive granite are less altered

If the suggestions that we have been considering are correct, the granite that first cooled ought always to be less siliceous than the granite intruded into it; while the veins of segregation or cooling (*granityte*) ought to be more siliceous than the rock in which they appear, and from which they separated; and this seems to be always the case in West Galway.*

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than those farther away. In the north of Ireland, at the Mourne intrusive granite district, county Down, the rocks next the granite are only very slightly altered, and apparently this metamorphism is much older than the intrusion of these post-carboniferous granites; while in the Carlingford district, county Louth, the carboniferous rocks (limestone), through which a large mass of granitoid elvanyte protrudes, are apparently unchanged. To the north of these districts the older intrusive granite of Newry and Slieve Croob, as proved by my colleague, W. A. Trail, F.R.G.S.I., has alongside in places rocks more metamorphosed than is general in the county Down, but this alteration is always very small, and does not appear to be general round the mass. It is also so slight, that all the metamorphic rocks in the vicinity of the Newry and Slieve Croob granite belong to the class called "Sub-metamorphic rocks" by the officers of the Indian Geological Survey. Trail has also pointed out that in those places where the derivate rocks are thus additionally altered, the adjoining granite is foliated; as if subsequent to the intrusion of the granite a strip of country had been invaded by heat (wet or dry), which had developed a foliation in the granite, and slightly increased the metamorphism of the adjoining derivate rocks; and this, he thinks, seems to be suggested by the action decreasing both ways as we leave the junction of the granite and the schist, at which line, naturally, the heat might be expected to be most intense. [*Note added in the press.*]

* This remark can only refer to a system of granites formed at one time; for if one system of granites were formed in the silurian period, and another in the carboniferous period, the basic granites belonging to the latter might occur breaking up through the highly-siliceous granites belonging to the former. Two quite different classes of veins are known as "veins of segregation;" one kind, which is always more or less regular, is due to a portion of the fluid rock segregating from the rest, and filling the shrinkage fissures and such like vacancies; to such veins the above remark applies. The other class is always most irregular, often lenticular, and appears to be due to minerals in solution, which subsequently crystallized, filling irregular vugs or cavities in the rock mass; to such veins belongs the rock previously described under the name of pegmatyte. Hunt, as previously mentioned, has suggested the name of *endogenous* for these vein-rocks or "granite vein-stones," to distinguish them from true granitic-dykes.—"Report, Geol. Surv. of Canada," p. 192.

XVIII.—On a Few Points in the Cranial Osteology of Sloths. By Alex. Macalister, M.B., Professor of Comparative Anatomy, Dublin University. (With Plate 13.)

[Read January 25, 1875.]

In the Museum of the University of Dublin there are several very good specimens of Sloths, some of which were brought home from South America by the Rev. J. M'Gregor Ward, lately Chaplain to H. M. S. Egmont, and some by Dr. Newton. In one of these, a very young specimen of *Bradypus gularis*, measuring only 10 inches in length of body, the skull exhibits several curious points.

1st. A vertical medial supra-occipital suture, extending from the middle of the back of the foramen magnum to the back of the sagittal suture. Then the supra-occipital consists of two lateral symmetrical pieces.

2nd. There are three wormian bones, two to the right, and one to the left of the median line in the place of the interparietal bone.

3rd. The post premaxillary tooth (Caniniform molar of Cholœpus) is very sharp-pointed, directed backwards and inwards.

4th. Owing to the absence of the frontal sinus (which in the adult *B. torquatus* occupies the whole of the frontal bone), the skull narrows from the parietal eminences forward. There are two slight fissures, one on each side of the middle of the frontal suture.

5th. The pterygoids have even so early a trace of the "Arctopithecus" thickening. The weak intermaxillaries are very faintly discernible, with a slight bony nucleus. In the accompanying Plate, figure 1 shows the back of the skull with the vertical occipital suture. figures 2 and 4 show the peri-orbital bones, and the relation of the lachrymal to the malar. Figure 3 shows the group of wormian bones. Figure 5 shows the solid stapes resembling the columella of birds, characteristic of the sloths.

XIX.—On Chlamydomyxa labyrinthuloides, nov. gen. et sp., a New Freshwater Sarcodic Organism. By William Archer, M.R.I.A. (With Plates 14 and 15.)

[Read February 22, 1875.]

Some short time after the appearance of Cienkowski's memoir on a new type of Sarcodic existences, met with by him in the sea (at Odessa), which he named Labyrinthuleæ, I was not a little surprised and interested on meeting with a form from the freshwater so wonderfully resembling those described by him, as, notwithstanding one circumstance, hereafter to be adverted to, even still to render it a matter of considerable question whether it may not truly belong to that group, even though it should not be congeneric with the typical Labyrinthula (Cienkowski).*

I regret indeed that, after repeated efforts to learn more of its development or history, I have but little succeeded, except so far as knowing that it is an endoparasitic growth, at least for a portion of its existence.

It will, perhaps, be the best course to endeavour first to give an idea of this curious production as it exists, before referring to Cienkowski's forms, which would, indeed, be necessary previous to comparing or contrasting it therewith, or with any other simple organisms evincing any similarity in minute specialities.

The component elements of the present form, broadly taken, are primarily divisible into two—the inner soft sarcodic body-substance, or contents, and the outer rigid cyst, or envelope, which nearly constantly surrounds the former.

But neither of these is quite simple, especially the latter, which presents a variety of constituents.

To advert briefly in the first place to the latter, the outer coat or envelope, its complexity consists, indeed, only in the number of similar layers of which it is composed, and its great irregularity of outline. It is often very thick, according to the number of laminæ of which it is made up, but even the thinnest, or such as possess but a single lamina, would, on the whole, be called "thick-walled" as compared with many vegetable cells. This wall is hyaline, and when viewed superficially it is colourless, or nearly so, but when viewed edgeways or at the margin of a many-laminated example, where a considerable density is therefore seen through, it appears of a pale straw colour or brassy hue, and extremely shiny and glossy. Its consistence is tough, requiring strong

* Cienkowski: "Ueber den Bau und die Entwickelung der Labyrinthuleen," in Schultze's "Archiv für mikr. Anatomie," Bd. iii., p. 274.

pressure on the covering-glass to burst it (Plate 15, fig. 4). As mentioned, its outline is most varied; globose or broadly oval might, perhaps, be called the typical form, but examples lobed in a variety of ways are extremely frequent. Nearly always, from one, two, or more places, are given off neck-like extensions, of greater or less width, terminating in a lacerated manner; these are produced, as it were, by the prolongations laterally of a certain number, greater or less, of the laminæ composing the wall, and then as if abruptly torn off. (Plate 14; Plate 15, figs. 3, 4, 5.)

Leaving the outer envelope for the present, and passing to the inner soft and plastic "living" portion, this is not a simple or homogeneous plasma or sarcode, but is itself composed of several seemingly distinct elements. The first of these is the basic substance of hyaline character, forming the common connecting medium of every other element (except, of course, the outer cyst or envelope alluded to) when the organism is in what may be called its state of repose—a state in which seemingly by far the greatest portion of its existence is passed. But at times a far more striking and remarkable phase presents itself, when further structural elements of the "living" portion or contents come to view, and to which I shall advert in the order in which they would most probably attract the attention of an observer examining an example of this production in "good order" for the first time.

Since I met with this organism, on the first occasion in a single pool in the Co. Westmeath, I have found it in several not very distant sites in Connemara, having since then learned to detect its presence in quantity by the reddish colour presented to the eye in the mass when it is in the dormant or encysted condition, so abundant does it eventually become in pools where it occurs. Upon the earlier occasions of taking it, indeed, the red colour was by no means so prominent a characteristic as it seemed to have rendered itself subsequently, but it was still a sufficiently striking feature.

In examples (especially as more lately taken) it is just this reddish colour which would likewise first attract notice under the microscope. This is due to a number of granules of varying magnitude, often rather large, but mostly very minute, with a dark outline and of a bright red colour. (Plate 14, fig. 2, to the right; fig. 4.) These may be often present in some examples in great abundance, sometimes in others more sparse, sometimes very few, or they may be in some specimens all but or quite absent.

Of the granular or solid contents, besides the red granules, others of a yellowish-green colour will attract attention. These are usually more minute than the larger of the red granules, but ordinarily surpass them in quantity, the red ones only rendering themselves more conspicuous at first and in the mass by their brighter and therefore more striking colour. The fewer the red granules the more abundant the green, and *vice versâ*. These green granules resemble much the chlorophyll-granules of certain algæ, though they are never of a grass-green, but are always of a yellowish hue. I suppose it to be very probable that the red granules are in reality produced by change of colour of the green. (Plate 14; Plate 15, fig. 2 to the left; fig. 4.)

But in the formation of the "contents" yet another granular constituent has a part. Besides the above-mentioned red and yellowish-green granules, minute homogeneous-looking rounded little granules occur, of a pale bluish tint. (Plate 14.)

When wholly encysted, and now in a completely dormant and quiescent condition, the organism appears very densely filled, and hence the larger examples are quite opaque.

The first and second year of my noticing this organism, in examples from the Co. Westmeath pool, quite frequently—since then from that site, as well as Connemara, very rarely—did I succeed in obtaining a view of the condition now to be described. It was therefore well to have secured the accompanying drawing, when the examples were readily found in suitable order.

Notwithstanding the seemingly tough consistence of the wall, or envelope, in manipulation, the contents have the power to burst or force their way outwards through it, and the basic plasma pours itself forth, bearing with it the granular contents as described, but not any of these escape or become scattered, for they are held together by the common medium, but, on the contrary, they pass onwards with it, and soon a remarkable sight presents itself. The plasma, thus become extended and spread out over a space so much greater than when it occupied the cavity of the envelope, now shows the contained granules mutually much further apart, rendering the hyaline connecting basic medium in itself more apparent. This does not seem to form a border, or any "ectosarc" region; the contained granules stand close up to the outer contour, leaving no hyaline margin. In examples presenting this condition in a well-expressed manner (Plate 14), I think I see yet another constituent of the basic substance, different from the common hyaline matrix—a kind of greenish, plastic, amorphous substance, as it were comparable to "diffused" chlorophyll, seemingly distinct from and yet, as it were, combining at the margins (if one may use the word) of the patches of it, with the hyaline matrix, than which, however, this substance appears to be of a less fluent or yielding nature. I do not think it would be capable of detection unless in examples so, as one might say, "on the stretch." Now, a beautiful play of quite globular *pulsating vacuoles* is seen to take place in the basic mass; these vacuoles, though very numerous, never become very largely distended. It is very interesting to watch their alternate diastole and systole, now here, now there, distributed all over the extended mass; but, to see this properly, attention should be confined to a single vacuole. It is curious to observe a vacuole originate in the middle of a layer of the greenish substance adverted to—the vacuole expands for a time in the usual manner, but, as if the expansion took place too vigorously in proportion to the yielding capacity of the surrounding substance, the latter becomes somewhat suddenly, as it were, *cracked* or *split* at opposite sides of the globular vacuole, the rift extending to a length, perhaps, as great as the diameter of the vacuole; anon the contraction abruptly sets in, and the divided surrounding substance *re-unites*, and the rift becomes obliterated (as it were re-fused), perhaps not to return, even should the vacuole reappear in the same place. (Plate 14. See the vacuole in centre of the subtriangular outlying portion of plasma to the left.)

But, as we watch, attention will soon be drawn off from the vacuoles. The first issuing portion of contents, upon being some time advanced into the surrounding water, forms, as it were, a primary trunk, which soon subdivides into a number of branches which taper off, or after tapering a little may again become expanded, forming a "peninsula" of the extended body-substance; or the connecting "isthmus" may disappear, leaving an "island" formed of the sarcode-substance lying apart. Presently, issuing from various parts of the "trunk" and principal "branches," as we have seen abounding in vacuoles, are soon noticed ramifications, extending far and wide in the most complex manner, *of filiform, hyaline, quite colourless threads of extraordinary tenuity*. These *extremely* delicate processes are flexible, but do not seem spontaneously to alter much in position as first developed, or at least very slowly, but only to grow in length and number. But, further, *pari passu* with their own appearance, occur at various distances upon them *minute fusiform bodies* of a pale bluish tint, their longitudinal axis posed in the direction of the length of the filament. At first glance these might momentarily be taken for so many fusiform expansions or enlargements of the delicate filament itself, offering a degree of (bluish) colour, owing merely to their greater thickness. But a closer inspection at once dispels this idea: *the fusiform bodies are seen to be in motion, though slow, along the hair-like filaments.* (Pl. 14, *passim.*)

A very few minutes' examination suffices to prove this. I regret I have not a note of their rate of progression; but if attention be bestowed on any few spindles (four, five, or six), at any given place on one of these capillary filaments, their relative distances will be noticed to have considerably altered in a few minutes. The little spindle, now in advance of several others, may slacken its pace as compared with those behind, or, what comes to the same thing, the hindermost may become accelerated; the natural result is that the foremost spindle is overtaken; it may then act as a temporary stop or barrier to the advance of those behind, and the little group may come to a standstill. They may then remain in linear sequence, or become, as it were, huddled together, and form a little cluster, but by-and-by they may resume their movement. But in such a case of a spindle now in advance becoming checked, what is more singular may sometimes happen—the hindermost may actually *creep over the lazy one in front*, and, this accomplished, then, nothing baulked, quietly pursue its way, leaving the spindle previously in advance of it far behind.

It is natural to speak of these minute travelling bodies as *spindles*, for that is their usual shape, but this can vary. In such a curious case as that just mentioned, of one of these bodies passing right over another in advance of it, sooner than allow it to remain a barrier to its progress, the former may assume a rounded or even a globose figure during the accomplishment of the act. (Its *sluggish* motion, and its often somewhat *slug-like* figure, as it slowly passes up and over its predecessor, seemingly at a standstill, might fancifully suggest a pair of *slugs*, unable to do more than creep, making an effort to accomplish between them but at best a very tardy game of "leap-frog!") But when the little travelling body has passed over the other, the fusiform figure is resumed. But normally, during progression, these bodies may sometimes represent rather a semi-fusiform figure, that is, one side may be *rectilinear*, this latter, when presented, being the side applied to the capillary filament upon which it travels, and the convex side raised up therefrom. During progression a still greater alteration of figure from the ordinary fusiform may present itself when one of these bodies arrives at a *fork* of the filament; then, as if it were uncertain as to which route it ought to take, it becomes itself bifurcated, and one leg follows one branch of the filament, the other leg the other branch, and so the little body,-now triradiate, may for some time remain stationary, as it were, *astride* upon the bifurcation.

These little eminently plastic bodies (one might roughly compare one to a piece of glazier's *putty*, or to *dough*) are, in fact, *identical with the little rounded or globular bluish homogeneous-looking little granules in the central mass* to which attention was at first directed, and which are *distinctly fusiform only when upon the capillary filaments*, although, indeed, before they arrive there they may, some of them, appear elliptic or subfusiform. That they are really one and the same thing, notwithstanding the difference of figure between them as a rule, is seen by watching the rounded granules deliberately proceed out of the general central mass and pass up along one of the filaments; as soon as it has done so and begins to travel upwards, the globose figure is lost and the fusiform outline is assumed. Soon follows another and another, in just the same manner, and a more or less long *cortége* begins its curious procession. By-and-by some of the little bodies may retrograde, remain stationary, or again advance, or all may become drawn in, capillary filaments and all, and the whole become reabsorbed into the great central mass. When one of the little spindles returns from its journey it passes down from off the capillary support and *reassumes a globose figure*, and joins the rest of the similar granules within the central mass.

It is when a great ramified *tree* is thus formed, under the observer's eye, perhaps in ten or twenty minutes, and numerous capillary filaments spread in every direction, up and down and laterally and round about, these well laden with *spindles* and the central mass thus thinned out and wide spread and relieved of so great a proportion of the granular contents, that the beautiful play of vacuoles referred to can be seen, and the whole object presents a spectacle, in its way, of unusual and exceeding beauty. (Pl. 14.) It must be borne in mind that the example figured, amply furnished with ramifications, and with a tortuous "labyrinth" of filaments, as it is, and well laden with spindles, as it appears, after all merely represents what could be seen in a *single focal plane*, whilst, perhaps, ramifications sufficient to make up several such complex "trees" occur in different planes between the slide and the covering-glass, and which can be made out by focusing up and down, all appertaining to the single main trunk, and derived in a brief period from the great common central head-quarters; nay, sometimes a secondary *colony* may be carried outwards and left apart at some remote point of the field, this latter now itself giving off minor branches and filaments back towards the *metropolis*. (See the more distant portion of Pl. 14.)

We have seen that these little bodies are of a homogeneous consistence, of a highly plastic nature, and of a bluish hue; they further appear to have no wall or envelope, that can be detected; still they do not mutually coalesce, and, however intimately they may be temporarily applied, a close examination will show their individual contours. I have not been able to see any subdivision of them. Their motion is a gliding one, and, as has been seen, it is always very gradual and easy, though sometimes slower, sometimes quicker, without any apparent rule or reason. Just as little rule or reason is evident in the course taken by the individuals, now of one and the same file—one may go the "main road," the other following it may take a "byway." Some reason, so far as it goes, appears why some should travel up the filaments and others remain behind in the general mass, in that it is seemingly just those which are most external, therefore nearest the place of origin, that is the base, of the filaments, which betake themselves thereon for the journey.

But if the variable rate and direction of the movement of these bodies be inexplicable, even still more enigmatical appears the cause, or the *modus operandi*, of the motion itself. One might suppose, indeed, that, once upon the filament, its elongation would cause the separation of the bodies and give rise merely to a seeming progression one from another. But we have seen their motion is a *real* one, and, in fact, automatic. They "spontaneously" leave the general mass, and, ascending the filament, commence their onward progress, and the latter, when once projected, seems to be even somewhat rigid, and incapable of imparting to them any impetus. The cause of the motion would seem, therefore, to reside in the spindles themselves: they are very plastic—they must seemingly be very contractile. But as they gently and smoothly glide onwards, as if without effort, and free from interruption, no very perceptible change of figure from the spindle-form is usually seen, except the flat form occasionally, or the furcate form more rarely, as before adverted to. In the case of two flattened spindles, they may sometimes be seen gliding at opposite sides of the filament, and one may pass the other with the filament between, and now without any change of figure, unlike what occurs when two or several meet at the same side and cluster together.

Not less curious is it again, seemingly, ***how these little bodies remain upon the filament***. What power keeps them there? They never seem to glide off or to be met with in the water around. In fact, these little performers on the "slack rope" seem to ***hold on*** admirably —but then their action is ***very*** deliberate!

I have sometimes supposed that, surrounding ***both*** spindles and filaments, a very subtle and delicate sheath, or envelope, must exist, of some amount of contractile power, whose action might exercise a propelling force to urge the spindles along the median axis, or, at least, to act as an auxiliary in conjunction with their inherent contractile locomotive power. Under a very high amplification indeed, I have thought to have seen such a delicate envelope, but I cannot say that the appearance might not have been due to an optical illusion.

However, such a structure would not be without parallel in certain Helizoan Rhizopoda, for instance, *Actinosphærium Eichhornii*, in which the radiating pseudopodia possess a central axis of firmer consistence (surely not comparable to a spicule), covered by a softer sarcode envelope, certain granules passing between, evidently carried passively by the latter. But the movement of the spindles, consisting, as it does, of a quiet and smooth glide, is of different character.. The axis of the pseudopodium of Actinosphærium, comparatively speaking, is a much coarser object than the delicate filament upon which the spindles travel in the present organism, and the soft involving granular sarcode of the former is indeed a very palpable thing as compared with the very subtle sheath assumed to possibly exist in the latter.

There exists a certain minute rhizopod, of which I have seen but very few examples, and have therefore had by far too restricted opportunity to study it, to give an account of or to describe it. *It is there*, however, and even, as is probable, I may not myself be so fortunate as to re-encounter it, it will most likely be found by other observers, and far better treated of. For the present purpose it is enough to mention that this form is of an orange or buff colour, globose its "normal" figure, but is capable of much alteration of outline, and it is furnished with numerous linear pseudopodia. Now, the point worth mentioning here is, that it possesses the power to eject with force, and rapidly, a considerable number, or (one might say) to "fire off" a simultaneous "volley" of its own orange granules, from all round its periphery, to a distance equal to the length of its pseudopodia, and with an amount of energy and consentaneousness which is truly surprising; no sooner, however, have the granules reached a tolerably equidistant limit from the periphery, than they begin to return, but, by comparison, much more slowly, and they become reabsorbed into the general central mass. This curious action I have happened to see on only two or three occasions, and under only a low power; I, of course, immediately turned on a higher power, but the performance so rapidly accomplished was over, nor would the perverse thing repeat it. Other similar forms evince comparable phenomena in a less pronounced degree. But the question comes up, how was this remarkable action effected? The little balls were suddenly ejected and gradually retracted, each in a quite straight radial line; they must have been held in by *something*, or they would have been shot off beyond recovery, either by a minute special cord of sarcode, rapidly evolved and again gradually retracting, or they must have passed either in or along the linear pseudopodia. If they passed up the middle of the pseudopodium, it must be capable of great distension, or, if upon the pseudopodium, they would seemingly be thrown off beyond retrieval, unless (like Actinosphærium) there were a subtle enclosing sheath over a central axis to keep them in. Whether then it is possible to compare the *modus operandi* of the rapid movement of the round orange granules of the rhizopod alluded to, if on the pseudopodia, with the slow gliding action of the "spindles" on the filtiform threads in the present organism, may be a matter of question.

Not less singular and curious than the spindles are the filamentary tracks upon which they travel. There is no perceptible differences in their width, or rather tenuity, either near the great main trunk, or at the remotest extremity, or after a ramification. The main trunk and the branches differ in size, as has been said, and a *branch* may become so small as to show the contained granules, evidently *within it*, in single file, and even of that degree of slenderness it is still recognisable as a branch, and it is at least as wide as a single granule or spindle. But the filamentary tracks proper are (by comparison) much narrower than the spindles, appear like delicate "silvery" lines (eluding observation sometimes, owing to being out of focus), and they do not give the idea of having the spindles *in* them (as does the finest branch), but *on* them, even when doubtless they are upon its upper or lower side, in relation to the observer. They are given off from all parts, even from the hinder portion of the mass still within the envelope, and it was not unfrequent to see a few spindles travelling from the margin of the body-mass to the wall. Further, it used not be unfrequent to see in a well-stretched out example that the granules remaining behind embedded in the mass, still in the head-quarters, showed more or less of a reticulated arrangement in rows, as if due to the presence of some of the filiform tracks permeating the interior of the unissued mass. (Pl. 14.) Still my impression would be that these remarkable linear tracks are comparable rather to pseudopodia, that is, that they are sarcode prolongations evolved *pro tempore*, and that there does not pre-exist a store of them, as it were, coiled up inside, waiting the occasion; on "squeezing" one of these no trace of them is seen in the mass. Unlike the axis of the pseudopodia of Actinosphærium, I have not seen that they penetrate downwards into the portion of the mass whence they emanate, and hence one of the most singular puzzles is that the little globular body about to travel, which without doubt is distinctly *in* the general mass, when it passes to the base of the filamentary track, ascends it, becomes fusiform, it *now* appears *on* it.

I have repeatedly tried in a variety of ways, by reagents, &c., to make out any structure of the nature of a *nucleus* in this organism, but in this I have failed. I could neither find a nucleus (as in Amœba, Pamphagus, Plagiophrys, Diaphoropodon, &c.) imbedded in the general mass, nor in the spindles themselves. The general mass is made up of the structures alluded to, and the spindles appear only as bluish plastic and quite homogenous bodies, as described.

Foreign incepted bodies, generally, if not always, algæ, were not infrequent. Sometimes one can see through even a densely filled and thickly enveloped and hermetically closed-in example the "digested" and defunct remains of perhaps a Cosmarium or Euastrum, &c., or an Oocystis or some such organism. (Pl. 14). The large example figured shows a brown and dead *Cosmarium cucurbita*, in another place an *Oocystis Naegelii*, equally brown and dead (but the characteristic arrangement of the endochrome not wholly lost), whilst next the extremity has been incepted an as yet scarcely altered example of a new and minute Spirotænia.* Around this has been consolidated the sarcode mass, which all the time gives off its filamentary tracks and spindles, the Spirotænia embedded in its midst.

Several times I have kept such glorious examples, as that figured, on a growing slide; after some hours the ramifications were drawn in, and there remained nothing but a "shapeless" mass sticking partially out of the torn opening of the envelope, or all had wholly disappeared. I never succeeded in directly tracing it, but there can be no doubt such can wholly retract and again secrete a wall, and completely shut itself up. Indeed it appears probable that an isolated or detached portion of the mass left apart also can so encyst itself—one might almost say indeed that this organism appears to have an *abhorrence* to remain long *without* a cyst; nay, even though seemingly the sarcode portion may not have emerged and offered the grand arborescent condition at all, still the contained mass will keep secreting a new coat, and adding yet another lamina to its perhaps already many stratified and much thickened envelope. And so, seemingly, after several egresses, retractions, recoatings, or subdivisions inwardly, and fresh recoatings, are brought about the numerous and manifold, often *outré*, shapes, in the encysted and dormant state assumed by this organism.

Anxious to find anything to indicate a reproductive process, I have delayed to bring forward even this so crude an account of this form; but in that hope I have failed. The only thing pointing thereto is a subdivision of the contents, sometimes noticed, into a considerable number of generally equal parts, sometimes a variation in size is noticeable. (Pl. 15, fig. 3.) These are globular in figure, and seem at first to be without any wall. Such, kept for a time on a slide, by-and-by collapse shapeless; if they had a wall they would not do so. But,

* *Spirotænia gracillima* (n. s. mihi), very minute, linear, extremely slender, very slightly tapering, apices blunt, spiral turns very numerous; a remarkable form, from its extreme slenderness. Breadth $\frac{1}{8000}$ to $\frac{1}{10000}$", about twenty to thirty times longer than broad.

true to the idiosyncrasy of this organism, in a normal state, each of the balls is not long without forming a special wall (as in the figure), and a number of globular, smooth, simple-walled, secondary individuals are produced in the cavity of the large multilaminated primary one. One sees before one an object *something* like an *oogonium* of a Saprolegnia, but there does not appear *any* analogy between them.

Such is an attempt to convey an idea of this organism, which may perhaps stand for the present as *Chlamydomyxa labyrinthuloides*, as it presented itself in the natural condition, especially the first and second seasons of my making its acquaintance. A word or two is requisite as regards the appearances under the application of reagents.

I was surprised, on applying iodine and sulphuric acid, to find that this curious multilaminated coat, so conspicuous a portion of the make-up of this organism, gave a brilliant indigo *blue colour*, accompanied by a great swelling up of the constituent laminæ, the outer of which took somewhat of a violet colour. (Pl. 15, fig. 6.) In other words, this coat gave in a marked manner the cellulose reaction. At same time the inner basic substance acquired a pale, homogeneous, somewhat verdigris green hue, and the granules, a brassy or yellowish colour, and shiny appearance, and became simultaneously of quite a spherical figure, and rather small and regular size, each with a dark contour.

Boiled in caustic potash, a great swelling up and separation of the outer laminæ of the coat took place; to some extent, the same in cold potash; the basic substance assumed a yellowish, sometimes faintly greenish, hue, and the granules became perfectly globular, more varied in size than under the iodine and sulphuric acid, but quite oily and shiny in appearance, and of a greenish-yellow colour. (Pl. 15, fig. 5.)

In Beale's carmine solution no very marked change ensued, and, as before mentioned, no portion showed itself anywhere as a nucleus, nor did any portion take indeed any extra dye.

Alcohol deprived the red granules of their colour, and changed the whole contents to a somewhat greenish-yellow.

Such were the results of reagents on this curious organism, as it presented itself, the first and second season of my meeting with it. Since then, much to my vexation, I have failed to encounter, except very rarely, examples displaying the active condition described; but it always now presents itself closely wrapped up in its coat, and densely filled with a preponderance of *red* granules. In that condition it is prone to occur, in considerable quantities, on the submerged surface of aquatic plants in the pools which it affects. The very first examples I met with were free at the bottom of the pool; and I therefore tried to examine this, to me, new phase more closely.

The first plant on which I noticed this was Sphagnum, but I soon found that this was only because other aquatics were more scarce in the pool; for the submerged leaves of sedges, of Eriophorum, &c., and more lately still, I noticed, in Connemara, that *Eriocaulon septangulare* also suited this organism as a host.

On examining a piece of Sphagnum, or other plant bearing this production, it may be often seen that the individuals are attached, sometimes in crowds, sometimes singly, by one of the before-mentioned neck-like prolongations, forming, as it were, a broad isthmus or neck, joining the great globose or lobed portion to the plant, but at other times they seem to lie thereon without any evident union with it. They are of variable size, and, as mentioned, of most variable shape.

But on closely scrutinising some of the Sphagnum-leaves (ultimately other leaves), I was still more surprised to find very *small* examples, with a simple wall, or perhaps with a wall of two laminæ, unmistakably *inside* the large hyaline cells, with annular and spiral fibre. (Pl. 15, fig. 2.) These little examples were in every respect (except size and number of laminæ of the coat) like the external larger ones; very small ones were of an ellipsoidal or subglobular figure, but larger ones, not uncommonly, showed an elongate torulose figure, simply due to the example, now enlarging so as to fill the cell, becoming at intervals cinctured about, and by reason of its expansive growth being constricted, by the recurring annular fibres of the Sphagnum-cell. (Pl. 15., fig. 2, middle and left.) Other cases could be found where such little examples protruded, hernia-like, on the surface of the leaf. Thereupon the "sarcode," with the granular colouring contents, seem to pass up into the protrusion; then, true to its propensity, to form a fresh coat, leaving behind the original one, and thus seemingly explaining how these bodies come to cover the leaf here and there, *attached thereto*. (Pl. 15, fig. 2, to right.) No clue whatever have I been able to obtain as to how these bodies originally get into the cavity of the leaf-cell, or how their "germs" can enter. No doubt, in Sphagnum, one could suppose small germs could enter through the pre-existent openings or foramina in the wall of the hyaline cells, and through the same openings the hernia-like protrusions could make an exit without any material injury to the Sphagnum; for it is true that, for a length of time, it can thus harbour this organism without seeming itself to suffer. But though this is so, it is no less true that when this organism at last grows to excess, the Sphagnum succumbs, gets eventually broken up, the tissue of the "leaves" disappearing, and nothing left but the "stem" and "branches" covered by this growth, and such portions seem to be at last utterly "killed."

But if it were supposed that in Sphagnum "germs" could make their way through the foramina in the cells of the leaves, the same supposition would not hold good as regards other plants, without such normal openings in the cells. Of such, none offers a more striking example than the cells (of the roots) of Eriocaulon. Of this curious plant, small specimens are sometimes found floating on the surface of the water, and though defunct, their tissues seem not in any way injured or disturbed. *Inside the cells* of this plant small examples of this organism are sometimes to be found, to all appearance hermetically closed in, and without any evident mode of ingress. But it would be unreasonable to suppose that it could be self-generated in the plants it inhabits. Other endoparasites, penetrating from without, as is well known, exist. In other leaves, where it can be seen occupying intercellular spaces, the marvel becomes, of course, very much diminished. It may be found (in Connemara) covering *Batrachospermum vagum*, and lodged in numbers between the cortical layer of filaments depending from the nodes, which become dislocated, and portions of the plant distorted; but such is not very surprising. But as to how this production gets *into* cells of several diverse plants, inhabiting the same pool, is a mystery to which I regret I have no clue.

In certain leaves of Sphagnum in which unmistakable young individuals occur, and again in others in which such did not reveal themselves (not always, however, absolutely critically examined), certain growths can be seen, generally somewhat to one side of the hyaline cell, and sometimes pressing in upon, and distorting, the intermediate chlorophyll-bearing cells. These form elliptic, greenish, coarsely granular masses, surrounded by an irregular, colourless hyaline, indistinctly bounded, roughly striate covering. (Pl. 15, fig. 1.) Sometimes two of these may occur in one cell, and if at the same level, or side by side, they together may press more upon the adjacent cells, and cause somewhat more marked distortion. I have not been able to satisfy myself that these have a genetic relationship to the subject of this paper, but I am inclined to think they may have.

Although, then, no "reproductive" condition or development of "germs" of any kind has ever rewarded my repeated collection and examination of this organism, at different periods of the year, so far as I am aware, nothing essentially agreeing with its general and special characteristics has before been described. But one cannot look at Cienkowski's figures of his Labyrinthula-forms, or read his account of them (*loc. cit.*), without being struck with the strong *resemblance*, if, indeed, it may not turn out to be more.

It becomes necessary, then, to refer to the description given by Cienkowski (*loc. cit.*), of the two forms for which he founded the genus Labyrinthula, and the only one of the new group "Labyrinthuleæ."

Labyrinthula vitellina, Cienk., forms little brick-red, or orange-coloured patches, about the size of a pin's head, upon seaweeds covering the piles in Odessa harbour. Placed under the microscope, and allowed to repose for some hours (say twenty-four), three principal constituents catch the eye of the observer: the "central mass," the "spindles," and the "filamentary tracks" ("Fadenbahn," Cienk.). The "central mass" consists of globules (0·012 mm. in diam.), with a very delicate contour, and of a brick-red or yelk-yellow colour, which in the aggregate are held together by a delicate, finely granular, basic substance, often presenting, externally, a thin colourless margin. Passing off therefrom in various directions are seen numerous slender, mostly very thin, anastomosing strings, the "filamentary tracks."

Towards the periphery of the mass the little orange-coloured globules acquire a more elliptic figure, and they can be watched passing up, one by one, upon the tracks, where they assume a fusiform figure, and gradually, but very slowly, glide onwards. In the course of several hours, the greater part of these little bodies have ascended the tracks, and slowly pursued their way to the margin of the drop of water. It is therefore clear the little globules at first seen, and the "spindles" afterwards found travelling on the slender tracks, are identical. Their contour is very delicate, they never become fused, though do not seem to possess any evident membrane. The middle of each is occupied by "*a nucleus*, appearing like a clear vacuole, enclosing a strongly refractive nucleolus;" they increase in number by self-division, and are hence to be regarded as true "cells." Treated with tincture of iodine, a sharply circumscribed contour makes its appearance on their surface, becoming brown, and standing off, more or less, from the contents. Alcohol dissolves the pigment, leaving the globules deprived of colour; the spindles so treated do not become blue by iodine, which at once takes place when tincture of iodine is added to fresh material; allowed to operate longer, the whole spindle becomes dark brown. The behaviour of the pigment under sulphuric acid shows it belongs to the category of colouring substances, forming the red specks ("eye dots") of Euglenæ, Rotatoria, the orange-yellow contents of Uredines. They are very contractile, altering their figure on contact as they glide along. Their main direction is centrifugal, towards the margin of the drop of water in which they are under observation, but they do not always take the shortest course; they appear also capable of gliding over one another; some of them thus delayed *en route* may preserve their original globular figure but having passed the obstacle, upon at fresh start the fusiform figure is reassumed. Sometimes, says the author, a backward motion may take place, "though indeed the final exit from the water appears to be the purpose of this curious wandering." As to the cause of the movement, the author knows of no fact capable of leading to an explanation, being of opinion, however, that, "owing to the rigidity of the track, the cause is to be sought in the spindles, though the latter, away from the track, have not the power to move."

Touching the "tracks" themselves, the author seems to regard them as not differing except in tenuity from the general hyaline basic substance. He was able, by the application of acetic acid, to perceive that the previously seemingly uniform substance now showed a very fine fibrous structure, and pressure on the covering-glass enabled him to detach the strings from the central body. When, however, the whole fabric becomes fully evolved under the microscope (that is, the whole "tree" or "labyrinth" developed), it seems to possess no contractility, evinces no movement on the surface or in the interior, no projection or retraction of processes or rays comparable to the pseudopodia of the Rhizopoda: the whole is now a rigid, motionless structure (except, of course, the wandering spindles). The author would leave the question an open one as to "whether the tracks represent a system of communicating tubes, or solid interwoven threads."

The principal difficulty in his arriving at a conclusion is due to the extreme minuteness of the threads, which scarcely allows of the mutual relation of these to the spindles being observed. The author could not satisfy himself as to whether the spindles executed their movement *in* a single thread or *between* two of them; as he regards the passage of a spindle, from the main filament to branch, as being compatible with either interpretation. Also, he says the fact that, upon the application of iodine, the contour then seems as standing off from the spindles, directly continued above and below into the filaments, may be used in favour of either view; this contour, with its dependent threads, may be interpreted as the expression of a "tube in which the spindle moves, or as that of two threads in contact longitudinally." The author himself leans to the latter view.

Notwithstanding the seeming *fibrous* nature of the mass under certain circumstances, and occasional tuft-like pencils of short linear prolongations making themselves sometimes apparent, Cienkowski thinks there is not thereby afforded a reply to the query whence properly the material to form the tracks proceeds; is it the basic substance of the central body which breaks up into the interwoven threads, or is it the spindles themselves which directly build up the whole framework? He replies, that naked clusters of spindles, or even isolated spindles, without combining basic substance, *are* so capable, and that the latter takes no share in forming the aggregate framework; but whether only the apices of the spindles or their whole surfaces contribute to emit it, he expresses himself as uncertain.

The other species described by Cienkowski, *L. macrocystis*, agrees in all essential points with the foregoing. Its spindles are larger (0·018 to 0·025 mm.), of firmer consistence, the nucleus more sharply marked, the contents more granular, than in *L. vitellina*, and they are colourless, or a pale yellow tint. Neither iodine nor sulphuric acid produces a blue colour. As in the previous species, the spindles increase by self-division. This form occurs on the piles at a higher elevation than the preceding, therefore not submerged except by the surf. Hence it is regarded by the author as explicable why, in this form, the spindles are more prone to pass into a "cyst" or "spore." Preparatory thereto, the cells enlarge, become more richly granulate, darker in colour, the spindles become oval, and each acquires, besides its own membranous covering, a thick-walled smooth envelope; the basic substance possesses a glassy, rather firm, consistence, retaining the outline, like a "mould" or matrix, of such "cysts" as are ejected by force; on the surface of the cluster there is formed a granular layer of darker colour than in the interior. After a pause, the contents of the encysted "spindles" become divided into four portions, the coat disappears, and they remain free, as motionless globules. This taking place, in many instances produce numerous closely lying little groups, the little bodies soon assuming the fusiform figure, already accompanied by the "tracks," indispensable for their movements.

Such is a very much epitomised abstract of the author's memoir, and he sums up the conception of the Labyrinthuleæ as follows:—

1. Clusters of nucleus-containing cells, increasing by division, possess a certain degree of contractility, at times becoming enclosed in a basic substance.

2. These cells give off a fibrous substance, which becomes formed into a rigid structure, forming reticulations and arborescent ramifications.

3. The cells leave the clusters, gliding away, by manifold circuitous routes, to the periphery of the drop, but the Labyrinthula-cells can carry on their wandering only when supported by these filamentary tracks.

4. The wandering cells combine anew in clusters, and pass over into an encysted state, each cell acquiring a firm envelope, all held together by the common basic substance.

5. From each cyst, after a rest of some time, four globules are formed, which extremely probably become changed into young Labyrinthula-cells.

Thus, notwithstanding the great resemblance, there are some points of difference, of such seeming great importance as possibly to forbid the present organism being subordinated to the Labyrinthuleæ. In the first place, the "spindles" are not nucleated; in the next, they do not (seemingly) ever become themselves encysted, but the aggregate group, matrix, colouring granules and all, become repeatedly so, and that in a cellulose coat; in the third place, Cienkowski's Labyrinthuleæ do not possess other colouring granules besides the spindles—in the present form there are green and red alternating; and, in the fourth place, the former do not show contractile vacuoles, a conspicuous feature in the latter, under certain conditions; nor did Cienkowski see any organisms incepted into their mass; and, lastly, Cienkowski's forms did not evince any parasitic nature.

The first objection seems to be the most important. Might it, however, possibly be met by assuming the spindles in the present form to be, as it were, *all nucleus?* Cienkowski offers no conjecture as to any seeming or probable purpose of the strange wandering of the spindles, save "to reach the periphery of the drop, or to get out of the water;" still he says they can recede. Their object would naturally seem to be to transport to a distance from the primary mass, and to distribute around, the spindles, in order to lay the foundation of a number of new centres. Quite in a similar manner, the spindles in the present form tend to pass away from the original centre, and masses, accompanied indeed by a greater or less quantity of the basic matrix, are sometimes left apart to form new centres. I cannot say, indeed, whether or not a single spindle would have the power to lay the foundation of a new and independent centre of growth, like to that which it left behind; but it might not be unreasonable to suppose that in this way the slender filamentary tracks, reaching far and wide, may be simply the medium of transporting to, and depositing these spindles within, the tissues of the adjacent submerged plants, in the way which we have seen it to occur, there to develop.

As to the second objection, that the individual spindles do not become specially encysted, but the whole of them, along with the other granular structures in common, might be only of secondary importance; more cogent, indeed, is it, perhaps, that they have not been seen to *divide*, but after all it is a probable way of their increase.

The remaining objections seem rather to relate to questions of habit, or might be considered in themselves as touching upon points rather of mere "specific" signification than of higher import. Cienkowski's forms might yet prove to be parasitic; they at least grow upon and surround the adjacent algæ. Cienkowski's forms took some twenty-four hours on a "slide" to grow up into a "tree" like that shown in his figures; the present form has often presented a spectacle like that shown in Pl. 14, in less than as many minutes.

If the spindles in my form were *nucleated*, i. e. if they represented "cells," not merely plastic, homogeneous, little masses, the present organism would seem to be necessarily relegated to the Labyrinthuleæ, apart from the other points of difference.

The "filamentary tracks" in Cienkowski's forms and in the present organism seem wonderfully to resemble each other, so much so that, whatever be their mode of evolution, it is probable this is alike in all. As has been seen, Cienkowski ascribes the origin of the filamentary tracks to the spindles themselves—in other words, a spindle must exist before a track; the former must first exude or give off the filamentary substance ("faserige Substanz"), then pass *along* (?), or *in* (?), or *between* (?), the threads so produced, but *which* the author leaves an open question. But this does not, seemingly, quite coincide with his description of the basic substance, a "zarte, feinkörnige Rinden-Substanz," often forming at the periphery a thin enveloping layer, where again its substance is spoken of as either "ganz hyalin, einförmig" or as showing a "sehr feine faserige Structur," and where it has the power to give off branches, of a glassy appearance, gradually tapering off; these may be of a uniform appearance, or show a very fine fibrous (faserig) structure, and at the margin sometimes running off into very thin, scarcely perceptible rays, sometimes fringe-like, at others tufted, and all this seemingly without the direct presence of any of the spindles. These fine linear threads seem to be nothing more nor less than the "tracks," as yet very short. In one form the tracks, if I mistake not, are given off independently of the spindles, but they are no sooner there than spindles are seen thereon (or therein?). As I mentioned as regards my form, and as will be seen in the figure, a more or less reticulated arrangement of the "spindles" (not *now* of fusiform figure) may be seen in the interior of the central mass, suggesting their arrangement along "tracks" enveloped by the general substance; but this is only conjectural. (Pl. 14.) In *both* Cienkowski's and the present form the tracks give off branches, and incorporate with others which they cross, admitting of the spindles taking very circuitous routes.

In Cienkowski's forms he mentions that the tracks (rigid as they seem at first) *by-and-by* take on "a mucous consistence, more or less enveloping the spindles," and they form "knot-like expansions, in which vacuoles occur;" but notwithstanding these facts, the author regards the tracks in such condition as only "most deceptively presenting the appearance of a protoplasm-plate;" does not this seem somewhat contradictory? In our form the tracks seem to be given off from the central mass (pseudopodium-fashion), and can be wholly or partially retracted.

Cienkowski denies to the spindles any power of motion *except in connection with the tracks*, but in both of his and in the present form these have the power spontaneously to leave the general crowd inside the central mass, at first without apparent contact with a track, then, *proprio motu*, to *mount* the one along which it is to make its journey.

But, further, in connection with a fungal, the identity of which was unknown to the author himself, Cienkowski had previously drawn attention to a filamentary form of plasmodium, with "spindles" moving along the threads.* This he describes thus (curtailed):—"Upon culture of these for some time upon a slide, I found the entire field covered over by a branched network of threads, which here and there showed fusiform thickenings. Upon following the course of these threads for certain distances, large differently-shaped colourless protoplasma-masses were encountered, from which the whole structure drew its material as from a reservoir—so to say, budded out from it. Upon attentive examination of the plasma-aggregates, it rendered itself apparent that, at any place thereof, a projection or prominence first makes its appearance. This prominence becomes constricted at its base, assumes a fusiform figure, then, removed from the principal mass, drawing a thread with it. In the same way sprouts out from the protoplasm a new spindle, which likewise thins off at its base into a thread, and follows the one first formed. Whilst thus continuously new spindles and threads proceed from the main reservoir, and become carried along the 'track' ('Fadenbahn'), the whole thread creeps forwards, the end spindle directed foremost. The filaments proceeding from the reservoir are to be identified with the basic substance of the plasmodium, the spindles and strings with the granular substance. The movement of the thread is extremely slow, scarcely directly perceptible, that of the spindle much more noticeable.

"*En route* the spindles may not be equally mutually remote; here and there one becomes accelerated, and lays itself longitudinally on the one preceding it; this is followed by another, and so on. In this

* Cienkowski; "Das Plasmodium," in Pringsheim's "Jahrbücher für wiss. Bot." Bd. iii., p. 408.

way originates a cluster of spindles which fuse together in a string, continuing its way; the thread, however, keeps its own position and extension. We are thus here compelled to distinguish between the less motile basic substance and a second gliding one. Another interpretation, that the spindles are but enlargements of the threads, which become moved up and down, is inadmissible, because the spindles, as we have seen, considerably alter their figure *en route*, coalesce, become divided, and proceed from the main reservoir."

The author, at the conclusion of his memoir* on the Labyrinthuleæ, again refers to this curious "Fadenplasmodium" appertaining to the unknown fungal (taken by him, he now mentions, from the earth of some flower-pots), and he regrets that he was never able to refind it for further examination, with the fresh light and new experience derived from the study of the two marine forms constituting his new group named Labyrinthuleæ. At that time, as is seen, he regarded "the central balls as protoplasmic bodies, from which each spindle upon beginning its wandering was produced by constriction. That the spindles pre-exist in the central clusters as such, or in the form of globules, was then a fact unknown to him, whether it were that this differentiation in the filamentary plasmodium (Fadenplasmodium) was not really existent at all, or that the delicacy of the object and the difficulty of observation concealed from him the true state of facts. The filamentary plasmodium observed under a covering glass always perished, for at that time he had made no use of the 'moist chamber.'"

There is thus pretty evidently a considerable resemblance in this organism, *whatever it be*, to that herein described.

The author alluded in his previous memoir on the Plasmodium to this "enigmatical" production, in order to compare it with certain very similar, though not seemingly at all identical conditions of the plasma of certain Mycetozoa.† Referring to certain filamentary forms assumed thereby, he draws attention to the "formation of lenticular enlargements of the basic substance of the threads. The number and size of these of course depend upon the persistence of the interruptions of the current, as also upon the quantity of the substance flowing onwards after each interval of pause. These isolated masses of the granular substance can glide along the thread up and down, approach, coalesce into a larger expansion, or become removed from one another; the basic mass of the thread remains also here motionless."

Now, I am much inclined to think that a comparison of the phenomena as here described by Cienkowski for the Fadenplasmodium in Mycetozoa, with those evinced by the organism brought forward by me in this communication, still less a determination of these as but the expressions of similar structures, would not be tenable. The appearances and characteristics evinced by my form seem more to admit of comparison with the fungal (from the flower-pot) referred to by

* *Loc. cit.*, p. 308. † *Loc. cit.*, p. 405.

Cienkowski; but there appear, so far as can be judged, general points of difference—of course no one could for a moment regard them as identical. If we judge aright from Cienkowski's figure,* the "spindles" in his unknown organism (from the flower-pot) do not seem of differentiated character from the tracks; they *seem* to be composed of the basic substance, and to contain the same extremely minute granules, notwithstanding that they have an independence of movement. Unlike the marine Labyrinthuleæ, they do not seem to be nucleated, and in that respect would agree with those of my organism. But in the latter the "spindles" are undoubtedly pre-existent in the central mass, and are of quite different colour, consistence, and character from the basic substance containing them, or the "tracks" on which they travel.

We have thus to do with an organism singular in its details, and highly puzzling as to its real nature—one which offers but few resemblances to recognised and described objects. Its outward "facies" and its most striking resemblances doubtless suggest affinity to the Labyrinthuleæ, especially *L. vitellina*, Cienk., but this *may* be a mere resemblance, nothing more, if we were acquainted with its development. It, like the marine forms, has a resemblance to Cienkowski's as yet, even to him, enigmatical fungal (from the flower-pot); it has a less striking resemblance to conditions of Mycetozoa, as pointed out also by Cienkowski. In the absence of a "nucleus" it agrees with Monera (Häckel). But, whilst it as yet shows no "fructification," no reproductive process, in any more strict sense of the word, a decision as to its real nature must remain in abeyance. Meantime, in itself and its specialities, it is an existence quite distinct from any other hitherto described, at least so far as I have noticed.

I am myself very strongly inclined to hold by the view that Sarcodic existence (at least those of the fresh waters), that is "Rhizopoda," in a broad sense, embracing various types, simple as they are, are, in fact, very fixed and permanent organisms. Bound up with certain "forms" seem to be their own inherent specialities of structure and of texture, their peculiarities of temperament (if one might be allowed to use the word in relation to so lowly organisms), their idiosyncrasies of behaviour, of manner, of habit, their peculiarities of colour, or its changes, their greater, or less, predilection for crude "food," or seeming total abstinence. Although, indeed, the present organism cannot be looked upon as belonging to Rhizopoda, it is, at least, not less strongly marked than any of the not very numerous but yet multifarious Sarcodic existences which the fresh waters, more or less abundantly or scantily, offer to notice. But still any generic or specific "characters" that could be ascribed to it would seemingly be of but a temporary or artificial nature, pending its further history. Since I first met with it, it has pertinaciously refused to present any additional

* *Loc. cit.*, T. xix., f. 5 and 6.

particulars as to its development. The nearest site at which I know it to occur is some sixty miles from Dublin; but I am inclined to suppose it will not turn out to be *very* uncommon; and at other seasons, or other localities, to other observers, it may unfold more of its history and afford further data, to throw a light on its true nature.

Ad interim, it may perhaps be well to epitomise its description, without attempting to refer it to any special class or order for the present, under the name of

Chlamydomyxa labyrinthuloides, n. g. et sp.

Generic characters :—

Body substance enclosed in a multilaminated cellulose envelope, whence, through an apparently lacerated aperture, the non-nucleated granule-bearing protoplasmic contents now and again emerge, irregularly giving off at the same time in an arborescent manner gradually tapering ramifications, and emitting numerous extremely slender hyaline ramifying threads ("filamentary tracks"), occasionally coalescing and forming a more or less complex "labyrinth," along which proceed from the central mass (as from a reservoir) numerous little therein pre-existent, non-nucleated globular, but plastic, bodies, which during progression assume a fusiform figure ("spindles").

Specific characters :—

Very variable in dimensions, in an early stage endoparasitic, that is, living within the tissues of aquatic plants; general mass, with or without subdivision, becoming periodically repeatedly encysted; enveloping coat hyaline, glossy, of a pale, yellowish colour, when viewed at margin (or through its greatest thickness); remaining thus long dormant, and in that condition the "spindles" globular; pigment-granules yellowish-green or bright red, rounded, or irregularly shaped, very dense; now and again putting on the energetic condition, and forming a highly ramified, arborescent structure, the central mass then presenting numerous rounded pulsating vacuoles; the "filamentary tracks" extremely slender, quite hyaline, the "spindles" bluish in colour, homogeneous in appearance, plastic, their progression slow, gradual, gliding; when in motion, about $\frac{1}{5000}$ to $\frac{1}{4000}$ of an inch in length, and about half as broad.

XX.—List of Seychelles Myrtaceæ, with Descriptions of two New Species. By J. G. Baker, F. L. S. Assistant Curator of the Kew Herbarium. (With Plates 16 and 17.)

[Read February 8, 1875.]

Genus Eugenia, *Linn.*

Sub-genus Jossinia.

1. *E. uniflora*, Linn. Sp. Plant 673, E. Michelii, Lam. D. C. Prod. 3, 263, Plinia pedunculata, L. fil. Suppl. 253, Bot. Mag. t. 473, Stenocalyx Michelii, Berg. A native of Tropical America, now widely naturalised in the Old World.

Sub-genus Syzygium.

2. *E. Wrightii*, Baker, Pl. 16. Branches straight, grey, terete, moderately stout. Leaves distant, distinctly stalked, ovate or oblong, 4-6 inches long, 2½-3 inches broad, cuspidate, broadly rounded at the base, rigidly coriaceous, shining, with the veinlets raised. Cymes copious, lax, stalked, lateral and terminal, 4-6 inches broad, with ascending main branches. Flowers stalked or sessile. Calyx ⅜-½ inch long, narrowed into a false pedicel in the lower half above the joint; lobes twice as broad as deep; tube not produced beyond the ovary. Petals round, ¼ inch deep. Stamens and style ½ inch long. Fruit not seen. Common in Mahè and Praslin. *Professor Wright! Horne!* Endemic.

3. *E. Sechellarum*, Baker, Pl. 17. Branches terete, moderately slender. Leaves distant, distinctly stalked, oblong, acute or acuminate, cuneate at the base 4-5 inches long, 1½-2 inches broad, rigid, with the veinlets raised. Cymes short-stalked, terminal and lateral, 3-4 inches broad, with spreading main branches; the flowers sessile at the end of the branchlets. Calyx ½ inch deep, turbinate, as if narrowed into a short pedicel above the joint, the lobes twice as broad as deep. Expanded stamens ½-⅝ inch long.

Seychelles, described from a specimen in the herbarium of the late Judge Blackburne, now at Kew. Resembles the common Asiatic *E. Jambolana* in leaf and general habit, but differs entirely in the flowers. Endemic.

Genus Barringtonia, *Forst.*

Sub-genus Butonica, *Juss.*

1. *B. speciosa*, L. fil. Seychelles on the shores, *Bojer. Horne!* (Common on the Mahè side of Praslin. Professor Wright.) Polynesia to Comoros, not Continental Africa.

Sub-genus Stravadium, *Juss.*

2. *B. racemosa*, Roxb. Seychelles on the shores, *Horne!* Spread through Tropical Asia and Africa.

3. *B. acutangula*, Gaertn. Seychelles, *Bojer.* Tropical Asia, not Africa.

XXI.—REPORT ON THE MICROSCOPICAL STRUCTURE OF ROCKS. No. 2. By G. H. KINAHAN, M. R. I. A., &c. (With Plate 8.)

[Read February 8, 1875.]

On the Quartz contained in the Granites from Knockanavaddy (B[1]), Ballynahown (B[2]), Furbogh (B[3] and B[4]), and Kirkullen (B[5]), County Galway.

The quartz in these granites occurs principally as the skeleton of the rocks; but a small portion is found as inlying blebs and crystals, principally in the orthoclase. The latter variety is very similar to the quartz blebs so characteristic of the elvanytes (Pl. 8, fig. 19).

The blebs of quartz in the elvanyte as a rule are in crystalline forms, or coated particles; some, however, are in irregular pieces, partaking more of the character of the skeleton quartz of typical granite. When typical they have sharp outlines, but in some the margin seems to graduate quickly into the surrounding minerals. Many of them contain a well-developed complete crystal of a foreign mineral (Pl. 8, fig. 19). All are affected more or less by gas specks or *labeculæ*. These, however, as a rule, are not numerous; and in those blebs in which many are found, the quartz occurs in a more or less irregular form. Short gas tubes, or *tubuli*, seem to be characteristic of the quartz of the elvanytes. In the right-hand quartz crystal (Pl. 8, fig. 19), under a power of 169, very few *labeculæ* appear, nor are they much increased in number under a power of 386. In the left-hand crystal, under a power of 169, there are also very few labeculæ to be seen; but under the higher power (386), about double the quantity appears, some of the latter being so small as to be scarcely visible, while in two places they form short strings of minute beads. In both crystals short thick tubuli occur. These, under a power of 196, appear as short thick lines; but with higher powers (from 250 to 400) they are seen to be minute tubuli, probably formed by gas. Fig. 23, Pl. 8, represents a group of them that occurs in the right-hand crystal. The two sharp cones are tubuli which lie oblique to the plane of the section. Some of the labeculæ, especially most of those that are complete spheres, seem to be gas bubbles, but many of the others, especially those that are oval and irregular in outline, would appear to be cross sections of the tubuli; their different shapes being due to the angles at which the tubuli are cut, and the reflection of the light against the walls of the tubuli. The crystals without sharp margin (left-hand fig. 19, Pl. 8) usually have more or less regular fringes of prismatic colours.

The skeleton quartz in the granites B[1], B[2], B[3], and B[4] has no crystalline forms, and gives a gorgeous change of colour when the polarizer is turned, the different masses of colour generally having irregular finely serrated thin fringes of other colour; while some have the irregular lines of that colour running through them. In specimen B^2 very little quartz appears in the slice, while in specimens B^3 and B^4 the fringes are very marked, and every group of quartz forms a patchwork made up of many small irregular portions. In the granite of Kirkullen (B^5), as represented in the slice, some of the quartz skeleton seems inclined to occur in crystalline forms, and in part to partake of the nature of the quartz of the elvanytes. Its quartz, when the polarizer is turned, is inclined to give more a *play* than a change of colours, while each piece usually has a fringe of prismatic colours. From this it would appear that the specimen of the rock was taken from a locality in which the rock had lost the true normal character of typical granite.

Fig. 18, Pl. 8, represents two small masses of quartz in the Kirkullen granite magnified to 42 diameters. In the right-hand one a crystal will be found with a power of 196 (see fig. 20, Pl. 8). In it are numerous labeculæ, some lying irregularly about, the rest more or less in lines or zones; there are also continuous lines, two of which are represented in the figure. With a still higher power (386), these lines are found to be strings of minute beads, apparently along shrinkage or fracture fissures. With the high power we also find that in places the labeculæ are systematically arranged, although with a power of 196 they appear to be irregularly grouped. This is apparent in fig. 21, Pl. 8, which represents the place marked *a* in figure 20, magnified 386 diameters, and shows there at least three distinct systems of labeculæ, which probably have relations with different facets of the crystal. The higher power also explains the elongated, pear-shaped, small, shaded spots in figure 20, which are found to be pointed clouds of minute labeculæ. In two places at the margin of this crystal there are clouds of small labeculæ.

The left-hand mass of quartz (fig. 18, Pl. 8) is different from that just described, as the labeculæ in it seem to be irregularly scattered about. Associated with them in places are short thick lines, few perfectly straight or symmetrical, like those in the quartz of the elvanyte (fig. 23, Pl. 8), but usually more or less curved or crooked, as represented in fig. 22, Pl. 8, which represents the place marked *b* in fig. 18, Pl. 8, magnified 296 diameters. There is also a peculiar feather-like arrangement, which is also shown in fig. 22, Pl. 8. Under a power of 386 the crooked and curved lines are found to be gas tubes or *tubuli*, while the feather-like arrangement is due to a line of oval spots which are the oblique sections of a system of minute tubuli. Five of these tubuli magnified 386 diameters are represented below, in figure 22, Pl. 8.

The labeculæ in the quartz are rarely visible when viewed with a less power than 50, while some are so small as only to be visible with a power of 400. A crowd of labeculæ occur at some of the margins of the masses of quartz, while the irregular lines, seen under polarized light, seem to mark the junction of two masses, or to be due to film filling a line of fracture. In the quartz of B^1 the labeculæ are sometimes in lines, but more usually they are irregularly scattered about. A well marked example of the feather arrangement (fig. 22, Pl. 8) was observed in one place, which under powers ranging from 300 to 400 showed distinctly the connection between this appearance and a system of tubuli; the feather on the right hand being the oblique longitudinal section of the tubuli, while the feather to the left was formed by reflected light, and disappears as the power is raised.

In the quartz of B^3 and B^4 some pieces have the labeculæ scattered about as in the quartz of B^1, and in them the tubuli appear to be rare; but in most of the others the labeculæ are in lines or systems, while the tubuli are not uncommon. These tubuli are usually more or less curved (fig. 22, Pl. 8), and rarely straight and symmetrical, like the tubuli in the typical quartz of the elvanytes (fig. 23, Pl. 8). In some of this quartz there are thin hair-like or capillary lines, not visible under a power of 230; these are long and short, straight and curved, and cross or branch from one another, a group being shown in fig. 24, Pl. 8. Some of these capilloids, under powers ranging from 300 to 400, are seen to be tubuli, while the nature of others, especially some of the long ones, may be different. The labeculæ associated with the capilloids, as shown in fig. 24, usually run in more or less regular systems. Some of these labeculæ, as previously mentioned in describing the quartz of the elvanyte, are undoubtedly bubbles, but some of them represent the cross section of the tubuli, the larger ones being sections of the short, thick tubuli, and the minute ones the sections of the capilloids.

In specimen B^4 a few of the pieces of quartz give a play instead of a change of colour.

In specimen B^5 the non-crystalline pieces of quartz, the labeculæ are very similar, and similarly arranged to those in the skeleton quartz of specimen B^1. Tubuli are usually scarce; those principally observed being capilloid.

The inlying blebs and secretions of quartz found in the felspars, but principally in the large twin crystals of orthoclase, are usually margined with a prismatic fringe, apparently due to a minute coated structure. They rarely have well defined margins, but usually graduate quietly into the envelope of felspar; many of them have a centre or nucleus of a foreign mineral. They contain more or less labeculæ, some being full of them, and in some were observed the capilloids and the short thick tubuli.

XXII.—Report on the Microscopical Structure of Rocks. No. 3. By G. H. Kinahan, M. R. I. A., &c., &c.

[Read February 8, 1875.]

Carnsore Granite, Co. Wexford.

The granite from which the specimen was procured occupies a small tract on the S. E. shore of Wexford, in the neighbourhood of Carnsore Point. The mass of the rock is evidently of metamorphic origin, but in the vicinity of the Point there appears to be an intrusive mass of slightly different granite. The typical rock is of a reddish greyish colour, containing large crystals, usually twins, of flesh-coloured or pink felspar, a dull white felspar, some greenish felspar, two micas, quartz, and pyrite. Of this granite, four slices were prepared by Mr. Jordan, of the Mining Record Office, two (B. 18 and 18*) from a block of granite near Castletown, and two (B. 22 and 23) from the rock at Crossfintan Point.

B. 18. This slice is principally occupied by one of the large crystals of flesh-coloured felspar. In the slice, the minerals observed with a power of 17 are: an irregular skeleton of quartz, three varieties of felspar, one crystal of amphibole, secretions of mica, and a few opaque crystals (pyrite ?). The large flesh-coloured crystal, which is probably orthoclase, has a lining structure that runs obliquely from right to left (see woodcut), but having darkly-shaded portions that extend irregularly from left to right, while scattered over it are numerous secretions of quartz. The second felspar [dull white] is semiopaque, but contains numerous iridescent spots; this evidently is a variety of orthoclase, and probably adularia. The third felspar only appears in small crystals, and portions of crystals; it shows minute parallel lines of prismatic colours, apparently being a triclinic felspar.

In this slice, most of the quartz occurs in the skeleton of the rock; however, a few particles were detected in irregular crystalline secretions, somewhat like the quartz characteristic of elvanyte. The micas, amphibole and pyrite (?) usually occur together, forming irregular nests; they are, however, sometimes in scattered small patches, while a few individual flakes or crystals were detected.

B. 18*. This slice seems to show the general character of the rock in mass. With a power of 17 the three varieties of felspar appear to be nearly equally developed. The quartz, besides forming the skeleton of the rock, appears in distinct crystals, while associated with the mica and pyrite (?) that occur in nests, is a bright green, beautifully iridescent mineral.

B. 22. This slice was cut from a specimen taken from near the margin of the mass of the granite, where it is slightly foliated. With a power of 17 the three varieties of felspar are apparent. The flesh-coloured variety shows some well-marked twin crystals; the iridescent semiopaque felspar is only sparingly developed, while the finely lined felspar crystals are well marked, this latter felspar also occurring in some places as thin envelopes to the semiopaque felspar. Of quartz there is a large proportion, while the amphibole is in excess of the micas; the last minerals and pyrite (?) occurring in minute crystals and flakes scattered about. In this slice was also observed the undetermined bright green iridescent mineral found in B. 18*.

B. 23. This slice is from a specimen procured a little north of B. 22, where the granite is distinctly foliated. With a power of 17, quartz is found to be the most abundant mineral, a large proportion of it being in distinct crystals. The three felspars appear to be nearly equally developed, while the flakes of the micas are minute and few. The amphibole is in small nests, or scattered crystals, while the pyrite is in most minute specks.

It should be mentioned that the character of the granite at Crossfintan is porphyritic, similar to the rock at Carnsore; and that the two slices [B. 22 and 23] just described, were, respectively, cut from places that seemed to show the general arrangement and proportion of the different minerals to one another; as always in the vicinity of one of the large felspar crystals; the other constituents of the rocks seem to have a peculiar arrangement.

From these notes on the granite of Carnsore, it will appear that it and the Galway granite previously reported on [Reports Nos. 1 and 2, *antea*, pp. 102, 161] are similarly constituted, and contain nearly identical minerals. Under higher powers of the microscope, it was found that the individual peculiarities in the different minerals were very similar to those to which attention was directed in those reports, no remarkable variation having been observed. It is, therefore, unnecessary to give detailed descriptions of them again, and I have confined myself to the general character, which seems to identify this granite with those of the Galway granite type, the principal constituents being three felspars [orthoclase, adularia (?), and oligoclase (?)], quartz (both crystalline and as the skeleton of the rock), amphibole, pyrite, and locally black and white micas.

XXIII.—On some Further Improvements of the Comparable Self-registering Hygrometer. By M. Donovan, Esq.

[Read February 8, 1875.]

Whatever length of gut-line may be employed in giving one round of the primary index, an equal length will be employed in giving every other, the gut-line being equal throughout; since that length is the natural unit, which, divided into the whole gut-line, gives for quotient the number of rounds which the primary index, under the circumstances, is capable of accomplishing. The spiral convolutions of the strands constituting the gut-line act simultaneously in all its parts, but diminish in effect from the bottom towards the top. Hence, the shorter the intercepted portion of the gut-line is, the less of the graduated circle will be traversed by either index in a given time, and the greater will be the total number of rounds performed by the primary. The revolutions of the primary index in the open air, therefore, virtually divide the gut-line into as many parts as that index performs revolutions round the graduated circle; the intercept, or what is the same thing, its effect in degrees on the graduated circle, being the natural unit.

According to the experiments of competent inquirers, the moisture of the atmosphere and of pervious bodies can be completely absorbed and withdrawn by exposure to the action of certain exsiccants, one of the most efficient of which is chloride of calcium. With this substance I proceeded as follows:—The hygrometer, fitted with a measured length of gut-line, perfectly dried in the exsiccating receiver during three days by means of ignited chloride of calcium, was placed in an artificial damp atmosphere, and so left for 24 hours, during which time the primary index had moved very nearly nine times round, and had begun to move backwards. A slip of wet blotting-paper being introduced into the receiver, the index continued to recede, some air having entered; but after a short while advanced, and at length reached zero, thus completing ten rounds, shortly after which it permanently ceased to move. Thus, in the open air, ten rounds of the primary index, or one of the secondary, cannot be exceeded, for they comprise all the degrees between extreme moisture and extreme dryness. The length of the gut-line exposed to the action of the exsiccant being 4·65 inches, and that of the intercept ·6 inch, the resulting normal number of calculated rounds by the primary index would be 7·75; and the unit *in the open air*, at this rate, would be by calculation 12°·9. But the experiment having been repeated in an artificial saturated *damp atmosphere*, the gut-line untwisted to ten rounds of the primary index, which, therefore, gave 10° as the unit; and the average of the differences in 10 rounds (viz., 10, 10, 9, 10, 11, 8, 12, 10, 10, 10,) gave 10° as the unit by experiment. Thus, calculation and experiment agreed exactly.

Should it happen, through any cause, that ten revolutions of the primary index do not measure the intercept in an artificial damp atmosphere, a new revolution will commence. When the secondary indicates 10° in the open air (which it will very rarely do), we say that the air is then saturated; but the affinity of the gut-line for water may not then be saturated. In an artificial damp atmosphere the gut-line will still absorb, and continue to turn the indexes until the gut-line be completely soaked, flaccid, and powerless.

It has been shown in my former communication* to the Academy, that a gut-string, as obtained from the music-seller, always contains water. This, being not water of composition, but hygroscopic moisture, may be abstracted without changing the nature of the animal matter that contained it. It obeys the law of the instrument with regard to absorption and expulsion. The indexes show how much had been already absorbed, by previous exposure, which now entering undistinguishably into present indications, keeps a running account of the total water previously absorbed or newly acquired.

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* *Vide* "Proceedings of the Royal Irish Academy," vol. i., ser. ii., pp. 476 and 556.

XXIV.—On two new Deposits of Human and other Bones, discovered in the Cave of Dunmore, Co. Kilkenny. (With Plate 18.) By Edward T. Hardman, F. C. S., F. R. G. S. I. (Of the Geological Survey of Ireland.)

[Read February 22, 1875.]

The Cave of Dunmore, situated about six miles from the City of Kilkenny, has been from very early times an object of much interest, and has been more or less fully described by various writers, the earliest of whom, as I am informed by the Rev. James Graves, M.R.I.A., was Bishop Berkeley. After him, many visitors have recorded their impressions of this weird locality, but the fullest account, which, indeed, like Moses' rod, swallows up or embodies most of the rest, is that of Dr. A. W. Foot,* who, in 1869, explored the place, in company with Rev. Mr. Graves and Mr. Burtchaell, C. E. He fully describes the principal features of the Cave, in his paper read before the Royal Historical and Archæological Association of Ireland, and gives an account of a quantity of human bones, which were obtained from one part of the Cave. I shall, therefore, make my descriptive remarks as brief as possible, as they must necessarily, in part, be a repetition of that and other papers. Dr. Foot shows that for at least two centuries this spot has been known to be a receptacle of numbers of human bones, which were said to have strewed the floor of it abundantly; but in modern times these have disappeared, and Dr. Foot's collection was obtained from a clay or silt bed, at one end of the Cave. He considers the bones to be the remains of natives slaughtered by the Danish invaders, about the tenth century. It is possible, however, that they belong to a much more remote antiquity.

At the time that I conceived the idea of examining this Cave for animal remains—in the course of my duty on the Geological Survey—I was quite unaware that any bones had ever been really got in it, although I knew there was a local rumour that some of those concerned in the rising of '98 had taken refuge, and died there. I was accompanied by Lieutenant W. W. M. Smith, of the Royal Artillery, and it fortunately happened that we picked up the same guides who had conducted Dr. Foot and his party. From them we learned of the find of bones, and were taken to the spot, whence we brought away many specimens. No other bone locality was then known to these men, but on a subsequent occasion Mr. Smith and I visited the Cave again, and

* An Account of a visit to the Cave of Dunmore, Co. Kilkenny, with some remarks on Human Remains found therein. By A. Wynne Foot, M.D., F.K.Q.C.P.I., Jour. Roy. Hist. Archæol. Assoc. Ir., vol. i. (Fourth Series), Pt. i., p. 65.

found at quite the opposite extremity of the Cave, and in a different chamber, two places in which bones were fully as abundant, not only human, but mixed or embedded with those of other animals, of which those of sheep or goat, pig and ox, have been identified.

To make my account intelligible, a short description of the Cave is necessary. The mouth of the Cave (see plan, Plate 18, fig. 1) which forms a rude arch, some 30 feet high, and about equal width, is approached from an old quarry, by a very steep incline, continuing into the interior some distance (about 200 feet). At the bottom it turns in to the left, and is at last stopped by a great bank of stalagmite, clay, and angular *debris*. This place is the lowest part of the Cave, and is called the "Fairies' Floor." Retracing our steps about half-way to the entrance, there is found a deep recess in the side. Entering this, it is seen to branch to the north and south. The northern opening is narrow, but enlarges after a little, and leads into a large chamber of very irregular height; in one place the floor coming within three feet of the roof. This is known as the "Rabbit Burrow," and at the extreme end of it (at *a*) is the deposit of bones referred to by Dr Foot. The southern passage leads, by a very rough and difficult way, to the "Market Cross," a very large chamber, so called from the magnificent stalactitic pillar which it contains, and which is represented in the accompanying sketch (Plate 18, fig. 2). This pillar cannot be less than sixteen feet high; the shaft is about four to five feet in diameter, the pedestal in the view given, from six to eight feet, but it is over twelve feet when looked at from the left,—the sketch, in fact, showing the narrowest aspect of the whole pillar. A second pillar, of nearly the same dimensions, formerly graced this apartment; but I am informed that a gentleman in the neighbourhood committed the vandalism of cutting it down to adorn his grounds. The examples seen in this part of the Cave, especially that before us, exhibit well the mode of formation of these pillars, and their gradual accumulation from ground and ceiling simultaneously, finally meeting and becoming one solid mass, then thickening laterally. Near this pillar are the two new localities for bones which we discovered. As the mode of occurrence of these deposits, and of that already known, is similar in all these cases, and involves points not touched on by Dr. Foot, I shall endeavour to describe it. I should first remark that Dr. Foot and his friends looked on these deposits entirely from an antiquarian point of view; and most naturally so, just as I myself, from the nature of my pursuits, had the geological and pre-historic idea uppermost in my mind from the instant I saw them: and in support of those views Dr. Foot quotes from the Annals of the Four Masters an account of a great slaughter at *Dearc-Fearna*, the "Cave of the Alders," and which he considers refers to the Cave itself. I am inclined to think, however, that it simply denotes the townland, or territory, so called, according to the usual custom, from the principal feature in it. The passage runs thus, the date being the Age of Christ, 928 :—

"Godfrey, grandson of Imhar,* with the foreigners of Ath-cliath,† demolished and plundered Dearc-Fearna, where one thousand persons were killed in this year, as is stated in the following quatrain:—

'Nine hundred years without sorrow, twenty-eight, it has been proved,
Since Christ came to our relief, to the plundering of Dearc-Fearna.'"

O'Donovan, in a note, says that the above was "probably the ancient name of the Cave of Dunmore." In the whole passage there is no reference to smoking out, or "smothering," which Dr Foot surmised may have been the means employed in reducing the garrison. The Cave was certainly not "demolished," and there could have been but little to plunder it of. Moreover, at the best of times the Cave could hardly accommodate a thousand persons, and the passage appears to me to apply only to the territory, where there may have been a large village. At any rate, it is but slender evidence on which to refer the bones to the Danish period; and there are certain circumstances that seem to render it most probable that these bones, even if not dating from one of the Stone Ages, are of much greater antiquity than the period of the Danish invasion. These I shall presently refer to.

At Dr. Foot's locality the bones occur at the base of a steep declivity, formed of a quantity of silt, sand, and clay, which rises at a sharp angle towards the roof, which it meets. This stuff, which is covered with stalagmite from one to four inches thick, is well stratified, and was undoubtedly brought in by water, through a fissure at the north end, now filled up. The following is the section, so far as it could be observed:—

SECTION AT END OF RABBIT BURROW.‡

	Ft.	In.
1. Layer of stalagmite, ...	0	6
2. Fine sand stratified, with rib of infant, —— —— in places,	0	6
3. Layer of stalagmite, which finally unites with (1), ..	0	3
4. Sand, ...	0	3
5. Dark carbonaceous and peaty-looking matter, .. 0 3—	0	4
6. Sand, ... about	0	3
7. Fine clay, stratified, ...	0	4
8. Coarse, loose, brown well-stratified sand, with fragments of decayed bone, ...	2	6
	4	11

The main deposit of bones occurs at the base of the incline, marked (*a*) in plan and section, but from the manner in which it has been disturbed, we could not determine their exact position. From the method

* Annals of the Four Masters, O'Donovan; 1st Division, vol. i., p. 623.

† Dublin.

‡ See Sketch Section, Plate 18, fig. 3. Throughout the Cave the floor is covered with large blocks of limestone, fallen from the roof, and now coated thickly with stalagmite.

in which this stratified deposit dips away from where it and the roof come together, there can be no doubt it has been introduced through an old opening or fissure which formerly existed here. It, with the included bones, could not by any possibility have been brought in by a stream or flood of winter rain-water, from the other parts of the Cave—as Dr. Foot suggests,*—for the stratification should run the other way, in that case, and the Cave should be nearly filled with water before a stream of any size could commence to flow in this direction.

The bones which we obtained from this locality are, without exception, human, and are mostly in a fragmentary condition, owing in great measure to the disturbance which the soil has already undergone. They comprise fragments of cranium, lower jaw, with teeth, vertebræ, humerus, fibula, ribs, patella, os calcis, &c., and numerous phalanges, which seem to be most abundant. It is sufficient to mention the fact of all these being human, however, for Dr. Foot, in the valuable paper cited, gives a complete list of all the bones he obtained, numbering 113 specimens. Our collection from this place numbers about 70, but some of these may be only different parts of the same bone. Yet, it shows what a quantity of human remains lie here. One fact worth notice is, that a pre-molar tooth is ground down to a flat surface, indicative of the owner having fed on grain, which had been ground up in some such rude implement as a quern, and thus plentifully mixed with sand. This would seem to point to an earlier period than the tenth century, when the Irish people were in a fair state of civilisation. I am informed by Rev. Mr. Graves, and also by Professor A. Leith Adams, F. R. S., that such teeth are not uncommon in the ancient Cairn-tombs or Kistvaens; but I am not aware if they have been observed in more modern cases, except perhaps in those of some ancient Egyptian skulls.

Another point must not be passed over, viz., the finding of bones in the silt itself, and under the stalagmite covering it. A rib of a young infant was found by us in the layers of sand six inches under stalagmite, and near the old opening, and consequently at a higher level in the Cave than the main deposit. Then in bed (8), which comes about three feet beneath the stalagmite, several fragments were found in a stratified layer, which appear to be the earthy remains of bone, from which all organic matter has been extracted. Professors Macalister and A. Leith Adams, who kindly examined my specimens, agree with me that some at least of these are bone.

I shall now refer to the new deposits discovered by us near the "Market Cross," at quite the other extremity of the Cavern, and some 600 feet distant from the last. (See plan, Plate 18, fig. 1, b.) These occur in precisely the same way; that is, at the base of, and interstratified with, silt, clay, and sand, which have come in through old openings, now entirely closed up.

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* *Op. cit.*, p. 76.

The first we examined forms a small recess, about ten yards from the "Market Cross," and to the left of the approach to it. We had, in fact, made this visit specially to make a survey, in order to determine where fresh explorations might be best made, feeling confident that the deposit described by Dr. Foot was but one of many in this Cave; and anything like a silt bed, or old opening, received our principal attention. This recess (fig. 4) was hidden beneath and behind large blocks of limestone, but well repaid our search, for a large deposit of bones was found; and nothing, I am convinced, but proper light, tools and labour, was requisite to enable an important find to be made. The sloping bed was encrusted with stalagmite; beneath, and encrusted in which are numbers of bones, not only human, but also those of the lower animals; all, however, recent. Some of those are encrusted thickly with stalagmite, or form a bone breccia. They have been identified as bones of sheep (or possibly goat) and pig, as well as human; the latter chiefly those of very young children. In fact, we hardly obtained a single bone approaching maturity in this part of the Cave. We also obtained teeth of sheep or goats, probably the former. The dip of the silt bed is here towards the north; just the reverse of that in the Rabbit Burrow.

A little nearer the Market Cross we come to another mass of silt, &c., dipping steeply to the north-east. It appears to be very thick. The hollow at the base of this contains quantities of bones, both human and others. We have obtained the lower part of a femur, and also a cervical vertebra of a small bovine animal, probably a calf, together with parts of the human skull, and other bones. Digging into the higher part of the bank of silt, we came to a layer of fine mud, or clay, containing fragments of bones, better preserved than those found under precisely similar conditions in the Rabbit Burrow, and admitting of no doubt whatever as to their character. As they are fragmentary, and much decayed, it would be useless to make out their species.

The bones we got from here have been determined as follows. For assistance in the identification I am much indebted to my friend and colleague, Mr. W. H. Baily, F.G.S. & L.S., &c., Palæontologist to the Irish Geological Survey. I have also pleasure in acknowledging the kindness of Dr. John Barker, F.R.C.S.I., &c., who allowed us to make use of the valuable osteological collection in the Museum of the Royal College of Surgeons, and also gave us his time and assistance in comparing the specimens. My thanks are also due to Professors Macalister and A. Leith Adams, who confirmed our identification.

LIST OF BONES FROM "MARKET CROSS" CHAMBER, DUNMORE.

Human.

Skull and Head, &c.	1. Temporal and tympanic portion.
,,	2. ,, ,, ,, ,, of child.
,,	3. Parietal. ,,
,,	4, 5, 6. Various fragments of skull, not quite mature.
,,	7. Basi-sphenoid and pre-sphenoid, young infant.
,,	8. Lower maxillæ, with canine tooth in pre-eruptive condition, *very young infant.*
Other Bones.	9, 10. Fibulæ of young infant, right and left.
,,	12, 13. Femurs of very young child, possibly new born.
,,	14–23. Ribs of very young child or children.
,,	24. Femur of older child.
,,	25. Os calcis, nearly adult (?).
,,	26–32. Scapulæ, mostly imperfect, of children of various ages.
,,	33. Portion of rib, adult.
,,	34. ,, ,, tibia.
,,	35. ,, ,, fibula.
,,	36. ,, ,, os calcis, young.
,,	37. ,, ,, ,, ,,
,,	38. Os calcis, adult, left foot.
,,	39, 40. Masses of stalagmite and bone breccia, with various fragments of skull, scapulæ, &c.

Other Animals.

,,	41. Bos (? calf), lower end of femur.
,,	42. ,, ,, second cervical vertebra.
,,	43. Sus, small species, upper end of right femur.
,,	44. ,, (larger individual), lower end of femur.
,,	45, 46, 47. Ovis (?), molars (3).
,,	48. Ovis (?), humerus, lower end of right.
,,	49. ,, or Capra (?), metatarsal set upright in stalagmite.
,,	50. ,, ,, metatarsal, set in stalagmite.

Miscellaneous.—Various pieces of bone breccia, or limestone cemented with stalagmite, and containing numerous fragments of bone, undeterminable. Also, in the stratified layers of silt, nearly decomposed fragments of bone.

A remarkable fact is the great number of infantile and immature human bones, some of the former being so young as to be nearly fœtal. Those of the pig are slightly blackened, as if by fire. Few of the bones show traces of having been gnawed by wild animals, although on some are marks that may have been produced in that way. Nor are they split, as if for the extraction of marrow, but that might have been accomplished by simply cracking them across. It is now hard to say whether they were broken as they are found, by accident or design.

I may be permitted to point out the importance of this find, for more than one reason. First, if we examine the literature of the Cave, as briefly summarised in Dr. Foot's paper,* we shall find that all the descriptions of the locality, where, from the remotest times, bones were known to occur, refer entirely to the Rabbit Burrow. A glance at the extracts given by him will prove that at once. But the last expedition before Dr. Foot's was undertaken by the Rev. Mr. Graves, Mr. Prim, and Mr. William Robertson, to clear up doubts expressed by a relative of the latter in notes of a visit in 1819, as to the existence at all, in the Cave, of bones, and of a well of water. These gentlemen concluded that he had only visited the "Market Cross" chamber, where (they considered) no bones were to be found, and came to the conclusion, *that human and other bones are confined not only to one chamber, but to a part of that chamber, and in the immediate vicinity of the well.*† And it is clear that all the observers considered the bones to have remained where they were originally deposited, without any reference to subsequent geological agencies.

Besides this, the discovery of these bones adds another link in the chain of evidence against the idea that all the bones in this cavern are those of persons who used it as a place of refuge from the Danes, and were slain there in the tenth century. Along with the improbability of people in a hurried flight taking in parts of animals to serve as food, and of their eating it in such uncomfortable and out of the way positions, it must be remembered that all the bones occur under the same conditions, in stratified deposits, under clay and silt, which must in part have come in later, and that by means of a considerable stream; nor could they have been introduced from other parts of the now known interior of the Cave, as the stratification runs the wrong way for this, and in a direction tending towards the present openings of the Cave.

My theory is, that these silt-beds covered with stalagmite, fill up the entrances to other chambers of the Cave at a higher level; that the bones formerly belonged to these chambers, and have been brought out

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* *Op. cit.*, pp. 67-72.

† Kilkenny Archæological Society Proceedings, Ap. 28, 1854. See Natural History Review, Vol. I., p. 175. The italics are in the original. Mr. Robertson refers to the "large fracture wantonly made in one of the stalactitic flutings of this bold pillar ('the Market Cross')." But this appearance is simply caused by the two portions of the pillar not having yet joined.

to their present position by water; and that this will quite account for such a disproportionate quantity of infants' and small bones, because naturally we should expect that the smallest, and, therefore, the lightest bones, would be brought down in largest quantity.

As a proof of the *possibility* of such upper chambers existing, I shall cite the case of the "Fairies' Floor," which lies to the north of the "Market Cross" chamber, but some twenty feet below it. These are connected by a fissure now nearly closed up, and the water has brought down a large quantity of silt and debris, covered with stalagmite, in every respect similar to the bone localities. (See Sketch, fig. 5.) When this is explored, I expect it will also yield bones.

The manner in which I have endeavoured to account for the bone deposits of this place is in accordance with Schmerling's and Lyell's doctrine,* that cave-earth, bone-breccias, &c., are produced by the sweeping into caves or fissures, by subterranean streams, of quantities of animal remains, together with fine clay and sand. There can be no doubt that some at least of these bones form part of a stratified deposit; but whence they came, or to what period they belong, are points which must be reserved, until further examination is made of the Cave; this I hope to be enabled to do this Summer.

The presence of the bones of such domesticated animals as the sheep, pig, and ox, especially the first, while it certainly precludes the reference of the human remains to a very remote antiquity, in a geological sense, yet allows of the idea that they may belong to the Stone or Bronze Ages. Sheep bones have been found along with bronze implements in Danish peat bogs;† also in a pre-historic burying-place, or cist, at Pickering, England,‡ in company with a stone spear-head, and piece of pottery; and are frequently met with in the Swiss lake-dwellings of the later Stone period,§ as well as a small race of pig. (It may be mentioned here that the pig bones found at Dunmore are either very young, or belong to a small species.) In Ireland itself, in the Crannoge of Lagore, bones of sheep, goats, oxen, swine, &c., were found associated with antiquities of Stone, Bronze, and Iron Ages, under sixteen feet of bog.‖

No flint implements, works of art, or articles of domestic use have yet been found in Dunmore Cave, but this may be simply because they have not been searched for. Mr. Graves told me he had not looked for any; and although Mr. Smith and I kept a look-out for anything of that kind, our time was too short to do more than lay the groundwork for future explorations; and as the bones occurred so plentifully, they kept our attention fully occupied. On the other hand, were these

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* Principles of Geology, Vol. II., p. 521, 10th Ed. Also Antiquity of Man.
† Antiquity of Man, Lyell (1863), p. 15.
‡ Pre-historic Times, Lubbock; Tables of Primary Interments, p. 97.
§ Lyell, *op. cit.*, p. 25, *et seq.* Also Lubbock, *op. cit.* p. 143.
‖ Lyell, *op. cit.*, p. 30.

bones so recent, as hitherto supposed, it might be imagined that modern implements, arms, &c., would have been found at some time in the Cave; but none are recorded. And it must not be forgotten that those things would not be so apt to escape the attention of ordinary observers, as flint weapons, and their accompaniments, which such persons would be most likely to regard as mere rubbish.

Another point I should refer to is the presence of peaty or carbonaceous matter in these Caves. This I have noticed in the section of the Rabbit Burrow. It has also been mentioned by Dr. Foot* as recorded by Mr. Robert Mallet so long ago as 1848,† that the charcoal of coniferous wood was found in layers in the stalagmite. Any charcoal that I saw was remote from the entrance, and interstratified with the deposit in which the bones were obtained; and had people fled there for refuge, and been undergoing the very unpleasant process of being "smoked out," they would hardly have tried to add to their discomfort by keeping up a fire in the interior. So that if it were even conceded that this charcoal was the result of fires used by regular denizens of the Cave, that would be sufficient to do away entirely with the notion of the Danish massacre.

In Mr. Mallet's paper, just cited, the occurrence of phosphate of lime in the stalagmite of this Cave is shown. He supposed it to be derived from the limestone rocks; but it is most probably due to the presence of bones. He does not seem to have been aware of their existence.

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* *Loc. cit.*, pp. 79-80.

† Journal Royal Geological Society, Ireland, Vol. III., p. 362.

1876, Feb. 26.

XXV.—ON A FOSSIL SAURIAN VERTEBRA, ARCTOSAURUS OSBORNI, FROM THE ARCTIC REGIONS. By A. LEITH ADAMS, F. R. S., F. G. S., Professor of Zoology in the Royal College of Science for Ireland.

[Read May 10, 1875.]

THE vertebra here described was presented to the late Mr. Salter, F. G. S., by the late Admiral Sherard Osborn, who brought it from Rendezvous Point, Byam Martin Channel, in the Arctic regions. I lately placed myself in communication with Admiral Osborn, with the view of obtaining further information on the subject, but regret to state that his sudden death prevented me from obtaining whatever data he might have been enabled to furnish in connexion with the history of its discovery and the conditions under which it was found. However, I am assured by the Rev. Dr. Haughton that he has a distinct recollection of seeing the fossil bone when in the possession of Mr. Salter, and, from a cursory examination at the time, was inclined to think that it might have belonged to Teleosaurus; at the same time, he informs me that there cannot be the slightest doubt as to its Arctic origin, which he ascertained previous to making the following record, published in the "Appendix to the Voyage of the Fox," p. 372. Referring to the above, and remains of a similar description, he states: "Captain Sherard Osborn also found broken vertebræ of a Teleosaurus, 150 feet up Rendezvous Hill, Byam Martin Channel, at the north-west extremity of Bathurst Island; they were certainly *in situ.*" Moreover, according to the determinations of this distinguished geologist, it will be observed that he considers the upper portion of Bathurst Island is composed of carboniferous limestone.*

The specimen in question was presented by Mr. Salter to Dr. Carte, F. L. S., Director of the Natural History Museum, Dublin, who has placed it in my hands for description.

With reference to other discoveries of a similar nature within the Arctic Circle, it may be stated that Sir Edward Belcher, Sir Leopold M'Clintock, and Admiral Sherard Osborn, brought many fossils from the group of islands lying between North Cornwall and North Devon. Among others were remains of Ichthyosaurus, determined by Professor Owen, and said to be from Lias beds.† These are the only Reptilian remains, as far as I can discover, yet described as Arctic fossils.

The specimen presents the following mineralogical characters, for the determination of which I am indebted to my friend M. Gages, M. R. I. A.

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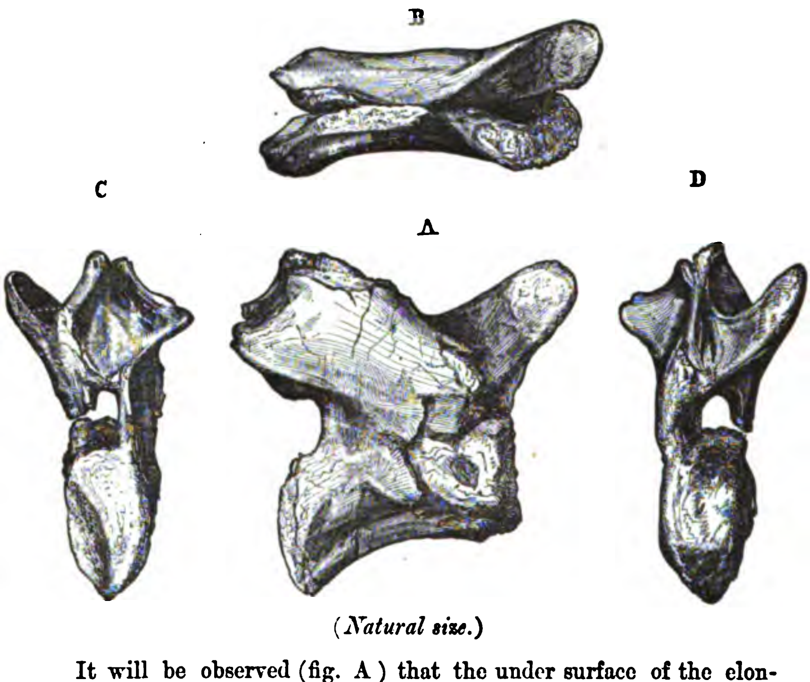
* "Geological Account of the Arctic Archipelago, drawn up from Specimens col lected by Captain F. L. M'Clintock, R. N., from 1849 to 1859," Jour. of the Geo Soc., Dublin, vol. viii., p. 196. By the Rev. S. Haughton, F. R. S.

† Appendix to "Last of the Arctic Voyages," by Sir E. Belcher, vol. ii., p. 389

"The phosphate of lime of the bone has not been entirely removed by the process of mineralization. There are incrustations of carbonate of lime in patches here and there, and it covers debris of quartz which, with numerous cubic crystals of iron pyrites, permeate the cancellated structure wherever the outer shining vitreous shell has been removed."

The following portions of the vertebra are deficient:—The neural spine is broken off close to its base; there is a loss of the right *pre-* and portion of the left *post-*zygapophysis, together with a considerable portion of the left half of the centrum. The outline of the centrum was evidently ovoid. There is a distinct cavity in front (fig. D), and although about one-half of the posterior aspect is lost, there are clear indications (fig. C), of a similar hollow, thus showing an amphicœlous structure.



(*Natural size.*)

It will be observed (fig. A) that the under surface of the elongated centrum is somewhat arched, the anterior portion being directed directly forwards, whilst the posterior points downwards and forwards, as indicating an upward neck curvature. The lower border of the centrum has been considerably injured laterally, but clearly it was narrow, and not broad and rounded. On its side there is a deep sulcus, pressed inwards.

The *dia-* and *para-*pophyses, so pronounced on the vertebræ of Crocodilia, and also the traces of the neuro-central suture, so generally present in this order, are, unfortunately, as regards the tubercula and capitula, undeterminable, from injuries to the outer shell; a crack, however, in the situation of the neuro-central suture may indicate the line of junction.

The *pre*-zygapophysis (fig. A), is produced with a deep *inter* zygapophysial pit (figs. B and D). The articulating surface is oval and plane, and the angle of inclination between it and the other is 50°: a still wider and deeper cleft intervenes between the posterior zygapophyses fig. (C). Both of the pits indicate powerful nuchal ligaments.

The base of the neural spine is compressed, and presents a hollow on either side (figs. A and B), with prominent ridges, which go to form the outer border of the *post*-zygapophyses. The latter are nearly horizontal (fig. C). In all these characters—to wit, the hollow at the base of the spine, zygapophysial ridge and posterior articular surface—it seems to agree with Lacertilia rather than Crocodilia. The cervical neural spine in Crocodilia is lengthened, and tapers towards a blunt point; whereas in Lacertilia it is shorter and broader in the antero-posterior direction, which, judging from the extent of the fractured surface (fig. B), was apparently the case also in the fossil. The neural canal is small and oval. Further there do not appear to me any points worthy of record.

I conceive that the bone may in all probability have been one of the middle cervicals of a Saurian, with bi-concave vertebræ. Compared with recent and fossil species of Reptilia, the above represents an animal between ten and twelve feet in length. Seemingly remarkable contrasts between the above and cervical vertebræ of Teleosaurus and other mesozoic crocodiles are in the produced *pre*-zygapophysis, sub-oval centrum, and the small size of the latter, as compared with the rest of the bone—to wit, height of the arches and massive ligamentous and zygapophysial attachments of this Arctic fossil, which would appear, moreover, to represent a considerably smaller species than either *Teleosaurus brevidens*, *T. cadomensis*, or *T. bubulidens*. The characters being narrowed to a few points in connexion with a single imperfect vertebra, I feel that it would be impossible to establish reliable comparisons between it and fossil genera of the Mesozoic formations.

It is to be regretted that, owing to the untimely death of Admiral Osborn, I have been unable to obtain further evidence as to its history. Admitting, however, its Arctic origin, as given by the late eminent palæontologist Mr. Salter, I propose for it the provisional name of *Arctosaurus Osborni*, in respect for the memory of this distinguished traveller, and in hopes that the naturalists of the expedition now about proceeding to the Arctic Regions will be enabled to verify these few data by fresh discoveries of a similar description.

XXVI.—INGENITE ROCKS. Report No. 4. By G. H. KINAHAN, M. R. I. A., &c., &c.

[Read May 10, 1875.]

LONGSTONE, Co. Tipperary, Ordnance Sheet 58.—An intrusive mass, coming up through the lower-bedded carboniferous limestone. This granitic rock is a more or less granular elvanyte, which may be thus described:—a slightly granular purplish brown color, weathering to a dirty reddish or orange. The base contains crystals of yellowish-greenish felspar, some small blebs of quartz, nests of minute greenish flakes (mica?), which congregate in a matrix that weathers ferruginous. In this protrusion there has not been a deep quarry opened, and, as the rock is more or less weathered to a depth of over twenty feet, it is impossible to procure a normal specimen of the rock, and, as may be expected, the slices cut are unsatisfactory, as the minerals they contain are more or less affected by rust stains. Under a power of 33 the rock seems to have a brownish felspathic matrix, containing numerous black, opaque, ill-defined crystals; and the latter, under a high power (327), are found to be crystals of pyrite changed on the edges into rust. In the matrix also are found numerous specks and small secretions of quartz; the latter, under a power of 258, are found to be arranged somewhat similar to what is shown in figs. 1 & 2, where the unshaded portions are the quartz; the obliquely-shaded portions, the felspathic matrix; the long crystals, appear to be amphibole, while there are bunches, or individual crystals (some well-marked octohedrons), of pyrite, or perhaps of a ferriferous garnet.

Fig. 1.

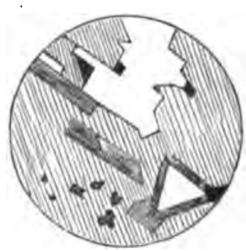


Fig. 2.

The mass of the quartz evidently has crystallized out after the other minerals, as it is found filling up the vacancies. In it were remarked lines, groups and scattered minute air bubbles, and some tubuli; in the sections examined they were not very numerous. In one piece of quartz forming a triangle (fig. 2), the plane is traversed by numerous irregular lines, giving the crystal a ruptured aspect (fig. 4); but under a favourable light they are found to be irregular minute black tubuli—some being straight, others curved, some oblique to or at right angles to one another, while some are short and others long. At the apex of the triangle there are a few air bubbles, but in the rest of it only one was detected.

The felspathic base, under a power of 386, shows a greenish-brown ground, thickly covered over with whitish dots, lines, and broken lines which are irregularly mixed up together; while in many places in it there are incipient forms, as if different minerals had attempted to crystallize out. It is also found to be principally a mixture of two felspars, one semi-opaque with irridescent spots, the other having a parallel play of colours; these seem to be most irregularly combined, but the latter apparently predominates.

The felspar crystals developed in the matrix seem all to have ill-defined margins. The most perfect seen in the slices is a twin crystal (fig. 3). Of these the left-hand member has an imperfect ribaned structure parallel to the long axis of the crystal; while in the right-hand crystal there is an obscure oblique structure. In all the crystals of this felspar there are inlying opaque black specks, probably of pyrite; the large black speck figured near the bottom of the left-hand crystal (fig. 3) seems to be a perfect hexahedron.

Besides the more or less regular crystals of felspar, there are irregular secretions, which consist in part of a semi-opaque irridescent felspar (*a*, fig. 6), containing, what seems to be nuclei, irregularly-shaped masses, (*b*) of a felspar, in which is a play of colours in parallel lines, similar to that displayed by a section of labradorite; while scattered about in the felspathic matrix are more or less well-formed small crystals (*c*), apparently of the same felspar as the first-mentioned nucleus.

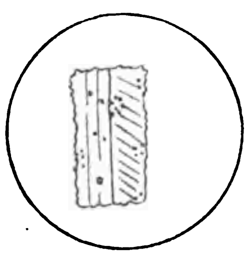


Fig. 3.

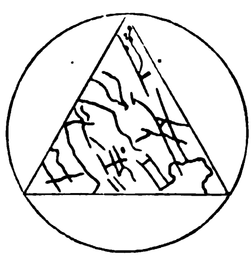


Fig. 4.

Two of the nests of greenish flakes, when magnified to 33 diameters, are figured (fig. 5). With a power of 385, the uppermost of these nests is found to be fringed by flaky crystals of an olive-green mineral, while the central portion is principally crystals of pyrite (?), with which are associated the olive-green mineral. In the oblique lower nest the olive-green mineral and the pyrite (?) are irregularly combined; but at the apex there is a great predominance of the pyrite.

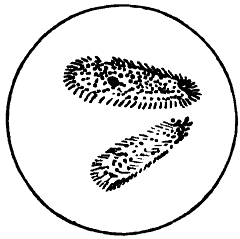


Fig. 5.

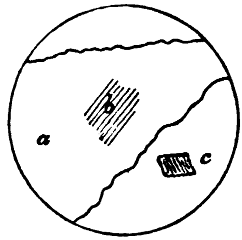


Fig. 6.

From the slices examined, the peculiarities of this elvanyte seem to be the nearly total absence of mica, except in nests, while the crystals or blebs of quartz, so characteristic in general of elvanytes, are nearly microscopic. The incipient crystalline forms in the felspathic matrix are also remarkable. But, as before mentioned, the specimens obtained were more or less weathered, and taken from near the margin of the mass. If, however, normal specimens could have been procured, and from places more deeply seated, it is probable that the porphyritic characters would be better developed.

XXVII.—ON SOME NEWLY OBSERVED PROPERTIES POSSESSED BY CERTAIN SALTS OF FULMINIC ACID. By EDMUND W. DAVY, A. M., M. D., Professor of Forensic Medicine, Royal College of Surgeons, Ireland.

[Read January 11, 1875.]

THE salts of fulminic acid, or the fulminates, have not received the attention which the interest arising from their extraordinary properties would lead us to expect. This is, no doubt, due in a great measure to their being such highly explosive and consequently dangerous compounds, which have already occasioned several serious and even fatal accidents to individuals whilst making them objects of research; they are, therefore, considering the amount of personal danger attendant on a study of their properties, not very inviting subjects of inquiry, and necessitate the exercise of much caution on the part of those engaged in their investigation.

The compound which is known to chemists under the name of fulminic acid, and which is expressed by the empirical formula $H_2C_2N_2O_2$, though it has never yet been isolated or obtained in the free state, is capable, as is well known, of forming a number of simple and compound salts, which are endowed with more or less explosive properties. Of those salts, by far the most important is the fulminate of mercury, which constitutes, as is well known, the active constituent of the percussion caps, and of the detonating matters which are used to fire the charges in our guns and pieces of ordnance; and for those purposes it is now manufactured in large quantities, and forms a very important instrument of modern warfare, since by its employment the use of flint and steel, matches, and other rude means of firing small and large guns have been quite abandoned, at least among all civilized nations.

Whilst making some experiments on the fulminate of mercury, I observed that when that salt and the ferrocyanide of potassium, both in aqueous solution, are gently heated together, the mixture at first acquires a faint reddish yellow tint, which quickly passes into a portwine or deep purple colour, without the separation apparently, at least at first, of any gas or solid matter. The development of this coloration, under the circumstances stated, being considered very singular, and hitherto unnoticed (as far as I have been able to ascertain), led me to study the matter more closely, to determine the nature of this coloured compound, and of the changes taking place in its formation.

On prosecuting this inquiry, I further ascertained that when the purple compound was fully developed, if the heat was continued for some time, or more quickly if the temperature was raised to, and maintained at the boiling point, the purple colour gradually disappeared, the liquid acquiring a light yellow tint, whilst more and more of a reddish brown solid matter (which was ascertained to be the peroxide of iron) was produced; these changes being accompanied by the evolution of more or less of ammonia, and by the mixture, which was at first quite neutral, acquiring a strong alkaline reaction. The solution being filtered, and concentrated by evaporation, was found to yield small prismatic crystals of a colourless or very light yellow salt, which appears to be a double cyanide of potassium and mercury.

Considering that the principal feature of interest in the reaction of the fulminate on the ferrocyanide was the formation of the purple compound, my attention was chiefly directed to its investigation. But I soon ascertained that this compound was a substance of a very unstable character, and that it presented great difficulties in the way of its separation from the matters with which it was associated, as procured in the reaction referred to; and not being able to obtain it in a pure or suitable state to submit it to actual analysis, I was for a considerable time unable to obtain any clue as to its real nature, further than it was some organic compound of iron, in which cyanogen, or at least its elements, were constituents.

At last it occurred to me, that the coloration observed might be in some measure connected with the formation of the fulminate of iron; and on making some of that salt, and comparing its reactions with those of the compound referred to, many points of agreement between them were at once perceptible. I may observe that the fulminate of iron is readily obtained by the action of metallic iron on the fulminate of mercury, suspended in water. Thus if about equal bulks of the fulminate and of fine iron filings are placed in a small stoppered bottle, which is then filled with distilled water, and being closed is occasionally agitated, the liquid in a short time acquires a yellowish tint, which gradually deepens in colour, whilst the filings become tarnished, and more or less of mercury, in the form of minute globules, make their appearance. After a few hours the decomposition of the fulminate of mercury will be more or less complete, and on filtering the mixture, a dull yellow liquid is obtained, which holds the fulminate of iron in solution. This fulminate, as so obtained, was described by my late father, amongst several other compounds of fulminic acid, which he was, I believe, the first to discover, during his elaborate researches on that acid. This salt was observed by him to produce, when treated with diluted acids, a fine red or purple colour, which disappeared after some time, evolving hydrocyanic acid amongst other products. He also found that a somewhat similar colour, rapidly changing to a bluish black, with a precipitate of that colour, was developed on heating this fulminate.

But this development of colour only occurs in the case of the freshly prepared fulminate of iron, for the salt, being one of very great instability, commences almost immediately after its formation to undergo spontaneous changes, which are attended by the separation of a dark brown substance, even when the solution is kept excluded from the air in a well-stoppered bottle; and after such changes have taken place, it ceases to develop, either by the action of acids or by heat, the coloration just stated. My father also observed that alkalies produced in freshly prepared fulminate of iron a dull green precipitate, quickly changing to a brown colour, which is obviously due to the separation of iron as an oxide from the fulminate of iron. And I have myself observed that the light yellow liquid which remains after the action of the alkalies and the separation of the oxide, at once develops a fine port-wine colour, when it is treated with diluted acids, and that the coloration so produced is much more stable than that developed by directly treating the fulminate of iron similarly; and that this red or purple-coloured compound resembles in all its characters that produced in the new reaction of the ferrocyanide on the fulminate of mercury already referred to.

As to the singular development of colour when the fulminate of iron is treated with dilute acids, I am not aware that any explanation has as yet been given; and the one that I would now suggest accounts for its production, not only in the case of the fulminate of iron, but also in the new reactions which I have myself recently observed; and explains some of the properties of this curious purple-coloured compound. To make the explanation I would offer intelligible, I should first observe that fulminic acid is generally regarded as a bibasic acid, which is capable of forming two classes of salts, viz., the neutral and the acid salts. In the first, the two atoms of hydrogen in the hydrated acid ($H_2C_2N_2O_2$), are replaced either by two atoms of a monad metal, as in the case of the fulminate of silver ($Ag_2C_2N_2O_2$), or by one atom of a dyad metal, as in the fulminate of mercury ($HgC_2N_2O_2$). In the second class we have either one atom of hydrogen still retained, whilst the other is replaced by a monad metal, as in the case of the acid fulminate of silver ($AgHC_2N_2O_2$), or two atoms of hydrogen are retained (the molecule of fulminic acid being doubled) where a dyad metal occurs, as in the acid fulminate of mercury ($HgH_2(C_2N_2O_2)^2$). Now as iron in most of its combinations plays the part of a dyad, we should express its neutral fulminate thus, $Fe\ C_2N_2O_2$; and when this salt is treated with a diluted acid there is formed, as I conceive, an acid fulminate of iron (a hitherto undescribed salt), by the following reaction, where for example, sulphuric acid has been employed, $2\ Fe\ C_2N_2O_2 + H_2SO_4 = Fe\ H_2\ (C_2N_2O_2)^2 + Fe\ SO_4$, and that it is this acid fulminate which possesses the red or purple colour, whilst it is at the same time much more stable or less prone to decompose than the neutral salt. If this acid fulminate is treated with an alkali, its purple colour disappears, owing, as I conceive, to the formation of a neutral double fulminate of iron and the metal of the alkali, which is a colourless salt in dilute solution; thus in the case of potash being added to the acid fulminate of iron, there would be a double neutral fulminate of iron and potassium formed, according to the following reaction: $Fe\ H_2\ (C_2N_2O_2)^2 + 2\ KHO = Fe\ K_2\ (C_2N_2O_2)^2 + 2\ H_2O$, and this colourless solution being treated with a diluted acid again develops the purple colour by the reformation of the acid fulminate, as the following equation indicates: $Fe\ K_2\ (C_2N_2O_2)^2 + H_2SO_4 = Fe\ H_2\ (C_2N_2O_2)^2 + K_2SO_4$. Or again, if to some freshly prepared fulminate of iron a dilute solution of caustic potash be carefully added, the mixture will continue (as I have observed) neutral so long as the alkali produces a further precipitate of the oxide of iron; and when it ceases to do so, if the mixture be then filtered, a light yellow solution will be obtained, which holds dissolved, as I conceive, a double neutral fulminate of iron and potassium resulting from the displacement of one half the iron in the neutral salt, as is shown in the following equation: $2\ Fe\ C_2N_2O_2 + 2\ KHO = Fe\ K_2\ (C_2N_2O)^2 + Fe\ O + H_2O$, and this double fulminate develops, as before observed, the purple coloration when treated with a diluted acid, and again becomes colourless, or very nearly so, on adding an excess of alkali, especially after the application of heat, and the colour can be again restored by acidifying the mixture, and these changes may be produced many times in succession.

For the production of the acid fulminate of iron the double neutral salt is much preferable to that of the simple neutral fulminate of that metal, as in the latter case there will be produced, as before shown, a protosalt of iron, which reacts on the acid fulminate, occasioning its more or less rapid decomposition.

I may further observe, that on heating the double fulminate just described, there will be developed the red or purple coloration, unless there is present too great an excess of alkali; this remark, however, does not apply to the case of ammonia, the excess of which being expelled by heat does not interfere with its production.

This development of the acid fulminate by heat is not so easily accounted for as where it has been due to the action of acids; it may, however, depend on the circumstance that the simple neutral, and double fulminate of iron, are both easily resolvable by heat under certain conditions into the acid fulminate.

I shall now point out how the explanation I have given of the production of the purple coloration in the case of the fulminate of iron may likewise serve to account for the similar development of colour, which I have myself observed, in the reaction of the ferrocyanide of potassium on fulminate of mercury. My experiments would seem to show, that when those compounds react on each other, there is at first formed, amongst other products, the double fulminate of iron and potassium, which, like that salt prepared directly, as already described, from the fulminate of iron, passes into the purple acid fulminate of that metal, on being heated or treated with diluted acids; the following formulæ and equation explaining the production of the double salt, accompanied, as it is in this case, by the cyanide of mercury and potassium: $2\ Hg\ C_2N_2O_2 + K_4\ Fe\ Cy_6 = Fe\ K_2\ (C_2N_2O_2)^2 + 2\ Hg\ Cy_2 + 2\ KCy$.

Amongst other facts which might be mentioned in support of the foregoing statement, is the following one, that I have observed, that when the ferrocyanide of potassium and the fulminate of mercury, along with water, react on each other at the ordinary temperature, the mixture after a short time acquires a yellowish tint, which gradually passes into that of a reddish shade, and if a portion of the mixture in this early stage of reaction be treated with a drop or two of any dilute acid, or is heated, the deep purple coloration which results when the double fulminate is similarly acted on will at once be developed. I shall now briefly notice some of the more characteristic properties of the acid fulminate of iron as obtained by the action of the ferrocyanide of potassium on the fulminate of mercury, most of my experiments having been made on that salt as so procured. When that compound is dissolved in water, it appears to possess, at the ordinary temperature, considerable stability, for it has been exposed to the air and even light in an open vessel for several weeks, without its appearing to undergo any change of colour; but when the solution is allowed even spontaneously to evaporate to dryness, the dark purple residue very soon passes to a brown colour, from the decomposition of this salt, and the separation of its iron in the form of peroxide; and this proneness to decompose in the dry condition may account for the residue not exploding on the application of a strong heat, the salt having quietly decomposed before reaching the temperature necessary to explode it, or other fulminates; and I may further observe, that even in aqueous solution it soon decomposes if the temperature is raised to the boiling point, its decomposition being attended with the separation of peroxide of iron and ammonia.

It does not appear to be soluble in ether, chloroform, bisulphide of carbon, or in benzole, though it is readily dissolved by alcohol.

It is quickly decomposed by strong acids, with the evolution of hydrocyanic acid and the development of Prussian blue, and even in their diluted condition the same occurs, but more slowly.

The caustic alkalies, at the ordinary temperature, slowly discolorize its solution; with the assistance, however, of heat that effect is quickly produced.

It appears to possess but little, if any disposition to assume a crystalline form, for as yet all my attempts to obtain it separately in such a condition have been unsuccessful.

Several experiments were made as to the effects of different metallic salts on this compound, but no very characteristic results were observable, except in the case of the nitrate of silver, which produced a dull bluish precipitate, leaving the liquid colourless, if sufficient of the silver salt be added. This precipitate, however, is one of great instability, for it very soon loses its blue colour (even when lying at the bottom of the stratum of liquid from which it has been precipitated), and becomes of a white or yellowish-white appearance.

If, however, while it still retains its blue colour, it is treated with diluted hydrochloric acid, or with an alkaline chloride, the solution regains its original purple colour, whilst the chloride of silver precipitates; but if the addition of the acid or chloride be delayed till after the precipitate has become white, then both fail to reproduce the purple coloration, owing to the previous decomposition of the silver compound.

This red or purple combination appearing to be but little affected by many of the metallic salts, seems to strengthen the view I have taken as to its nature, for had it been a peculiar cyanogen compound, such as we have in the case of the ferro-, ferri-, and nitroferri-cyanogen, as well as in other compound salt radicals of that substance, we should have expected that it would have produced very characteristic effects with different metallic salts.

I may further observe that the same compound is formed when the ferricyanide of potassium (or as it is better known under the name of red prussiate of potash), instead of the ferrocyanide of potassium (the yellow prussiate), in aqueous solution is heated along with the fulminate of mercury, and that it, as well as the ferrocyanide, even without the application of heat, give rise to, but more slowly, the formation of the red or purple combination, the ferricyanide acting, however, in this respect more readily than the ferrocyanide.

Lastly, I may add that I found that a similar purple compound was produced when the fulminate of silver was substituted for the mercurial salt in the reactions referred to, and it is probable that some, at least, of the other fulminates would give rise to like effects.

I regret that the results which I have brought before the Academy are not, in some respects, of a more definite character; but all who have experimented on the fulminates have experienced the great difficulties of such inquiries, arising from their instability and complexity of constitution; but I hope before long to be able to investigate more fully the subjects of this communication, as well as other matters bearing on them. I trust, however, that the results of the observations which I have already made may not be considered as devoid of interest, as any facts which may extend our knowledge of fulminic acid, a compound regarding the true nature of which chemists are not yet agreed, must possess more or less interest in a scientific point of view; and it is well known that many facts and observations which at first have been regarded as mere matters of interest to men of science have afterwards proved of much practical utility.

XXVIII.—ON THE CONSTITUENTS OF THE TWO PRINCIPAL MINERAL WATERS OF LISDOONVARNA, COUNTY OF CLARE. By LANCELOT STUDDERT, LL. D., Ex-Sch., T. C. D., and WILLIAM PLUNKETT, F. C. S.

[Read May 24, 1875.]

BEFORE proceeding to Lisdoonvarna the authors procured, in July last, a jar of the principal sulphur water of the place, which was carefully collected from the Gowlaun Well, through the kind aid of Dr. Cullinan, of Ennis; of this a preliminary examination was then made at the laboratory of the Royal College of Science, Stephen's-green, Dublin.

In August they visited Lisdoonvarna, in order to determine at the springs the sulphuretted hydrogen that might have escaped, and the iron that might have become peroxidised before reaching Dublin; and also for the purpose of procuring a large supply of the waters, to determine their more stable constituents. This lengthened investigation the authors were kindly permitted by Professor Galloway to conduct in that laboratory, with all appliances available.

Remaining at Lisdoonvarna until the 5th of September, they repeatedly estimated at the well itself the sulphuretted hydrogen in the Gowlaun Spring, and in a secondary one, near the east end of the parish church. They also determined the iron present as protoxide in a principal, and also in a secondary, chalybeate well, both situated in an enclosure at Rathbawn Bridge, nearer to the town of Lisdoonvarna.

It may be right, perhaps, to remark that there are no interments in the churchyard; that spring there issues from the cliff-side, and is one of a pair of spas, sulphur and iron, in one recess, and nearly joining at their mouths, thence called the "Twin Spas." The iron one was not flowing in September last; and neither of these seems to have been sent for analysis to Professor Apjohn in 1856. There was indeed another chalybeate water sent then to the laboratory of that eminent chemist from the "Spectacle Bridge" Spa, still farther from Lisdoonvarna town; but the well is now closed by cattle tracks, and is reported by a writer (Dr. Faussett) to have been disused in 1867.

The temperature (which is said to be equable) of the two sulphur and two iron spas so examined by the authors was ascertained as compared with that of the atmosphere; also the rate of flow of the "Twin Sulphur Spring;" but the underground position of the springs at Gowlaun and Rathbawn prevented their rate of flow being determined. However, notwithstanding their many drinkers, the level of these two principal wells is said to be rather constant.

It should be noted that during this visit, and for some days before, the weather was wet. The rain seemed to dilute the spas; for even the drinkers remarked them weaker in taste. The explanations to accompany Sheets 114, 122, and 123 of the maps of the Geological Survey of Ireland, illustrating parts of the Counties of Clare and Galway, by Mr. Frederick J. Foot, M. A., give the geological formation of the Lisdoonvarna district, which may account for the nature of its springs. At page 27, Mr. Foot observes that "Iron occurs in the form of ironstone nodules and thin bands in the shales about Lisdoonvarna, . . . also as iron pyrites, with the crystals of which mineral (he adds) the black fissile shales, when they are unweathered, may be seen coated." He seems correct in remarking (page 28) that "It is from the decomposition of the iron pyrites [sulphide of iron] in the coal measures that these wells [at Lisdoonvarna] derive their sulphur and iron."

It may be added, in passing, that Mr. Foot gives a correct woodcut of the "Twin Spas" as Figure 9 of his report.

Following the suggestion of a recent eminent writer, from a medical point of view, on these and other spas of Ireland (Dr. Mapother), who advised lithia to be looked for in the Gowlaun water, the authors made that search by means of the spectroscope, and the presence of lithia (by its distinctive band) was ascertained, but in amount too minute for a quantitative determination in the supply of water available. This constituent seems to have been detected in this water now for the first time. Dr. Mapother relies on it as a curative agent of much value.

Another medical gentleman, Mr. William Faussett, M.B., F.R.C.S., who visited Lisdoonvarna in 1867, as he says, "for his own health's sake," states, in an account of his visit (page 13), that "The sulphur and chalybeate springs of Lisdoonvarna, when judiciously used, and supplemented as occasion, in some cases, may require, possess an extensive range of therapeutical action; and being free from the excess of any irritating ingredients, such as common salt, will, on this account, be found more beneficial than spas which have hitherto been held in higher repute."

Since then (it seems it was, that) the present excellent pump-room was built over the Gowlaun Well. In September last the local physician, Dr. Stackpoole Westropp, was erecting some baths near it, much desired by patients and their professional advisers. Dr. Apjohn remarked, in 1856, that the Gowlaun water was "used externally as a bath."

Of the several springs at Lisdoonvarna two are chiefly resorted to, namely, the before-mentioned sulphur spring known as Gowlaun, and the principal chalybeate spring at Rathbawn. The following are the results of the examination made of them:—

GOWLAUN.

The temperature of this water, as drawn from the well, was found to be 11° C., the air at the time being 15.5° C. It contains, in addition to the usual constituents of well water, 5.553 cubic centimeters of sulphuretted hydrogen in the litre. The unoxidized sulphur exists entirely combined with hydrogen. It also contains, as before mentioned, traces of lithia. The following table gives the quantities of the several constituents :—

	Parts in one million.	Grains in one gallon.
Silica	13.6	.952
Sulphuric acid, calculated as SO_4	10.0	.700
Chlorine	29.6	2.072
Lime precipitated on boiling, calculated as Ca ..	35.0	2.450
Lime retained in solution on boiling, calculated as Ca	2.7	.189
Magnesia precipitated on boiling, calculated as Mg	17.1	1.197
Magnesia retained in solution on boiling, calculated as Mg	1.4	.098
Lithia	Traces.	Traces.
Soda, calculated as Na	61.9	4.333
Potash, „ K	3.0	.210

Which may be calculated as being in combination thus :—

Silica	13.6	.952
Calcic carbonate	87.5	6.125
Magnesic „	60.1	4.207
Sodic „	102.3	7.161
Calcic sulphate	8.1	.567
Magnesic „	6.0	.420
Sodic chloride	44.4	3.108
Potassic „	5·7	.399
	327.7	22.939
	c. c. per litre.	
Sulphuretted hydrogen	5.553	

The specific gravity referred to water at 15° C. was 1.0006.

RATHBAWN CHALYBEATE.

The temperature of this water was found to be 13° C., when that of the air was 15°.1 C., being a difference of only 2°.1, whilst in the case of the Gowlaun water, the difference was 4°.5 : this may be accounted for by the more open situation of this well, which is more freely exposed to sunshine. This water contains, in addition to the usually occurring substances, a ferrous salt, and also a weighable quantity of manganese; this latter substance does not appear to have been before detected. The several constituents are :—

	Parts in one million.	Grains in one gallon.
Silica	12.1	.847
Sulphuric acid, calculated as SO_4	124.7	8.729
Chlorine	35.5	2.485
Iron, calculated as Fe	17.1	1.197
Manganese „ Mn	0.8	.056
Lime precipitated on boiling, calculated as Ca ..	56.0	3.920
Lime retained in solution on boiling, calculated as Ca	24.8	1.736
Magnesia precipitated on boiling, calculated as Mg	2.7	.189
Magnesia retained in solution on boiling, calculated as Mg	16.8	1.176
Soda calculated as Na	20.5	1.435
Potash calculated as K	2.5	.175

Which may be calculated as being in combination thus:—

Silica	12.1	.847
Ferric oxide, with trace of alumina	2.7	.189
Ferrous carbonate	31.7	2.219
Manganous „	1.7	.119
Calcic „	140.0	9.800
Magnesic „	9.5	.665
Calcic sulphate	84.3	5.901
Magnesic „	84.0	5.880
Sodic chloride	52.1	3.647
Potassic „	6.4	.448
	424.5	29.715

The specific gravity referred to water at 15° C. was 1.0006.

In the same enclosure with the last mentioned, is another chalybeate, know as the Magnesian iron water. As it has now fallen into disuse, it did not seem necessary to do more than determine the iron which it contains. Calculated as carbonate, it was 14.9 Mgr per litre, or 1.043 grains per gallon.

Of that remarkable pair the "Twins," only one—the sulphur water—was flowing; it is essentially of the same character as the Gowlaun water. It contains 2.052 cub. cent. sulphuretted hydrogen per litre. The temperature was 11°.6 C., the air being 15°.4 C. The rate of flow was found to be one litre discharged in one minute and twenty seconds, or about ten gallons in one hour.

XXIX.—On the Ligamentum Mucosum. By Arthur Wyndowe Willert Baker, B. A., Student in Medicine, Trinity College, Dublin.

[Read April 27, 1875.]

The ligamentum mucosum of the knee joint being so very slightly noticed by anatomists in general, and the information respecting it so scanty, it has been suggested to me that I should keep notes of some of those I found during the past winter session, and these notes I now bring under your notice.

Before giving the result of my own observations, it may be necessary to review the literature of the subject. The first notice of it, of which I am aware, is by Vesalius (Op. Venetiis, 1568, p. 270), who records its existence in these words:—"Verum praeter hoc ligamentum interdum adhuc mucosum quoddam et gracile reperias, in medio genu articuli locatum." The anatomists who followed him added nothing to his description until the publication of Walther's Observationes de articulis et ligamentis incessu, statuque, &c. (Lipsiæ, 1728, p. 8), who refers to its relation to the mass of fat. But the fullest of the old descriptions is that of Weitbrecht, who, in his Syndesmologia (Petropol., 1742), says, "Ex ejusdem zonæ pinguedinosæ sede inferiore educitur appendix aliqua ejusdem substantiæ sed plurimis fibris intexta, ope quarum in latere dextro sulci, qui est anterius juxta capitulum externum femoris supra ligamentum cruciatum anterius cui accumbit infigitur. Hæ fibræ an duplicaturarum continuationes sint, an vero ex ipsa patella proveniant ut Winslow vult difficulter extricari potest, magis tamen assentiendum Walthero mihi videtur qui id de pinguedine terminari perhibet." Referring to Winslow's description shows us that it is an incorrect one, as even in the fifth edition of his "Anatomical Exposition of the Structure of the Human Body" (1775), he says (p. 130), "it is attached to the lower part of the cartilaginous side of the patella by one end, by the other to the anterior part of the great notch between the femoral condyles." He says its use is to hinder the fat from being compressed in motion of the knee. Other old anatomists, Kerckring, Blancard, &c., add nothing. Among the modern anatomists the ligament is passed by with as trifling notice. Boyer names it the adipose ligament. Cruveilhier (Anatomie, 1834, p. 469), says that sometimes it is absent, sometimes multiple; he has seen a fold of this nature stretching from the membrane over the extensor tendon to the supratrochlear part of the femur. Mr. B. Cooper in his Lectures (1829, p. 275) says it is composed of a number of little fimbriated processes which receive the branches of the articular artery. Barkow calls it "ligamentum suspensorium marsupii," as he has named the alar ligaments the "marsupium patellare." Henle* says of it, "The

* Bänderlehe, 2nd edition, p. 153.

origin, strength, and connexions of this ligament are variable. I saw it of the thickness of a coarse thread only, made up of an arterial and venous stem, and a pair of bundles of connective tissue; usually it is flat and broad towards its insertion, cylindrical medially, and knotty by its including several fatty lobes." Luschka says,* "That only exceptionally does it form in man a membranous sagittal septum, which completes the partition of the synovial cavity of the knee into two lateral halves, a partition partly begun by the crucial ligaments." Roberts† adds little more in his monograph. Hyrtl remarks, "In spite of its slenderness and often thread-like proportions, this band is called the mucous ligament; it is often absent or appears knotty from including fat, or it includes a fibrous string which conveys blood vessels to the patella, these seem to fill vacant spaces in the joint." Cloquet describes it as an adipose canal.

Before bringing forward the details of my own observations, I wish to explain the following division which I have adopted.

Class I. Contains those cases where the ligament formed a complete septum across the joint.

Class II. Where it formed a partial septum.

Class III. Where it existed as a coarse thread or threads.

Class IV. Where the ligament was absent.

To this I have added notes on the comparative anatomy of the ligament.

The total number of cases occurring in each class, together with the average strain it took to break them, is as under:—

Class I. There were 9 cases (22½ per cent.), average strain, 21.24 lbs.

Class II. There were 9 cases (22½ per cent.), average strain, 15.00 lbs.

Class III. There were 19 cases (47½ per cent.), average strain 9.19 lbs.

Class IV. There were 3 cases (7½ per cent.)

Class V. There were 20 cases.

In Class I. the measurements were taken in this manner:—

Anteriorly. From the marsupium to the femoral notch.

Posteriorly. From the anterior crucial ligament to the femoral notch.

Above. The femoral attachment.

Below. From the marsupium to the anterior crucial ligament.

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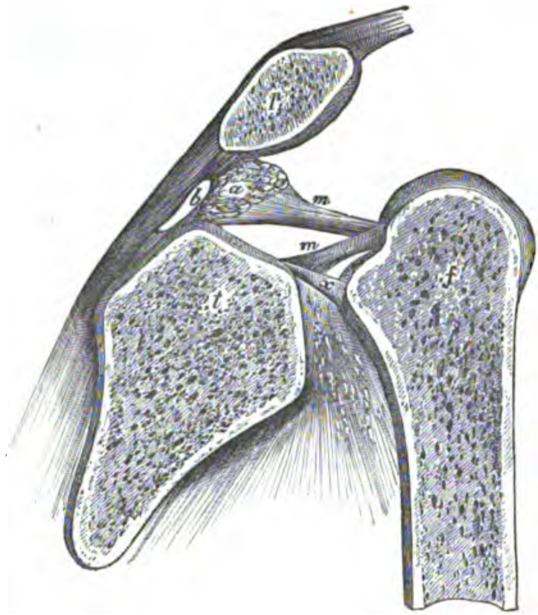
* Nur ausnahmweise bildet das ligamentum mucosum beim Menschen ein membranöses sagittal gestelltes Septum welches die schon durch die ligamentum cruciatum eingeleitete sonderung des gelenkes in zwei seitenhalften vervöllstandigt, Anat. des Menschen, 1865, Bd. 3, pt 1, p. 376. [I am indebted to Dr. Macalister for the translations].

† Untersuchungen über die anatomie und mechanik des kniegelenkes, Giessen, 1855.

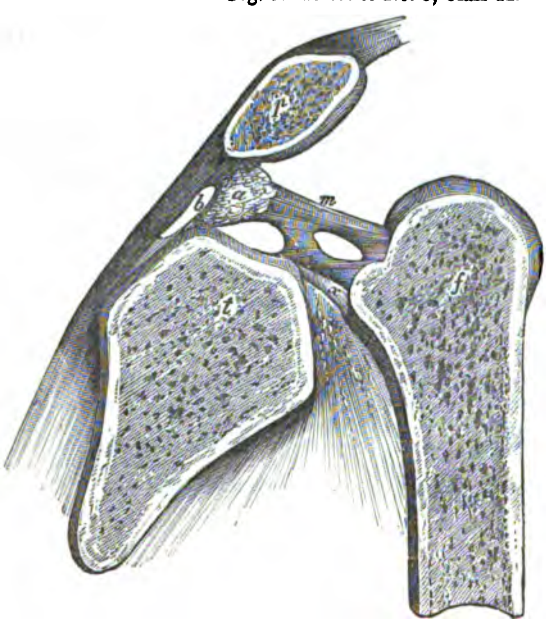
CLASS I.—COMPLETE SEPTA.	Sex.	Side.	Marsupium to Notch.	Marsupium to Crucial lig.	Crucial lig. to Notch.	Femoral attachment.	Broke with a strain of
			Inches.	Inches.	Inches.	Inches.	Lbs.
1. The first complete septum I saw, I regret I was unable to measure, as it was a very fine specimen.							
2. The ligament was attached to the external side of the femoral notch, and contained a vessel.	M.	R.	1.25	1·10	0·75	0·90	21
3. The fellow ligament of No. 2 carried several vessels, and was attached to the external part of the notch; I also observed a second mucous ligament going from the marsupium to the snyovial hood which is often found on the internal condyle. Though a mere thread, this ligament was of considerable strength, having a triangular origin and insertion; it measured 1.25 inches in length, and is the second of the kind I have observed in man.	M.	L.	1·00	0·95	0·55	1·00	28
4. There was no communication between the subcrureal bursa and the synovial cavity of the joint; the inner condyle had a free fimbria attached to it.	F.	L.	0·75	0.90	0·70	0·90	24·5
5. Was composed of separate threads at the anterior portion; was fellow of No. 4.	F.	R.	1·00	0·80	0·50	0·90	14
6. Was broader at the anterior portion, and T-shaped, like the ligamentum mucosum in the Otter.	F.	R.	0·75	0·85	0·70	0·70	19
7. Was slightly notched at its femoral attachment, and had no trace of any vessel; but there was a slip going from the middle of the ligament to the external side of the femoral notch.	F.	L.	0·75	0·85	0·85	0·90	14
8. No trace of any vessel; in testing the strain it broke cleanly from its femoral origin.	M.	L.	0·60	0·85	0·55	0·80	28·5
9. Was so much inflamed that I did not think it worth while testing the strain.	F.	L.	0·80	0·70	0·85	0·40	—

Fig. 1. Refers to No. 16, Class III.



p = Patella.
a = Mass of fat.
b = Bursa.
t = Tibia.
f = Femur.
x = Anterior crucial ligament.
m = Ligt. mucosum.

Fig. 2. Refers to No. 3, Class II.



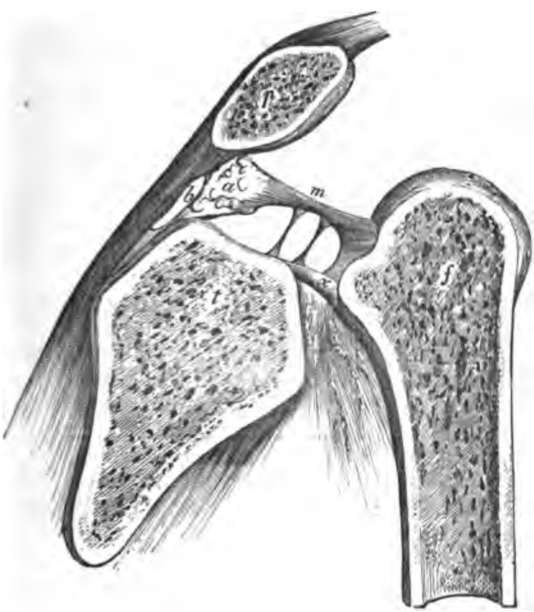
p = Patella.
a = Mass of fat.
b = Bursa.
t = Tibia.
f = Femur.
x = Anterior crucial ligament.
m = Ligt. mucosum.

CLASS II.—PARTIAL SEPTA.	Sex.	Side.	Length.	Width.	Broke with a strain of
			Inches	Inches.	Lbs.
1. Had a falciform edge at femoral attachment.	F.	—	0·80	0·30	21·5
2. Had a falciform margin looking downwards and backwards.	F.	—	0·80	0·30	16·0
3. The ligament was inflamed, the subject itself was old, thin, and had numerous bed-sores upon her. Fig. 2.	F.	R.	0·55	0·90	29·5
4. Had a falciform margin. I had not weights to measure what strain it would bear.	M.	R.	0·70	0·20	—
5. Had a falciform edge, and broke from its femoral attachment, where there was some trace of a vessel.	F.	L.	0·60	0·25	10·5
6. A rickety subject, in whom the testes had not descended; the ligament carried many vessels. I observed a fine thread extending from the middle of the ligament to the anterior crucial ligament at its latter extremity; it expanded into a reddish cone-like thickening; this thread measured 0·6 inch in length.	M.	L.	1·00	0·40	14·0
7. The fellow limb of No. 6 had a slight falciform edge, and broke from the marsupium; notwithstanding its being a smaller ligament than the preceding, it bore a greater strain, in consequence of a large vessel running along the posterior margin, which came from the azygos articular artery.	M.	R.	0·80	0·15	15·5
8. Had a falciform margin, a second slip went from its femoral attachment to the anterior crucial ligament, and a third slip joined the marsupium to the outer reflection of the synovial membrane; the vessels on its surface were from the internal and external superior articular arteries; there was a hood on the inner condyle.	F.	L.	0·80	0·35	7·0
9. Had a falciform femoral attachment; two threads went from this ligament to the anterior crucial ligament, and a third thread joined the marsupium to the external reflection of the synovial membrane; there was a hood on the inner condyle. Fig. 3.	M.	R.	1·20	0·30	6·0

Class III.—Coarse Thread or Threads.	Sex.	Side.	Length.	Width.	Broke with a strain of
			Inches.	Inches.	Lbs.
1. A coarse thread.	M.	—	0·90	0·20	1·0
2. Was double at its origin and insertion; had a trace of a vessel at its insertion.	F.	—	0·65	—	2·5
3. Carried a vessel from the superior external articular artery.	F.	—	0·95	0·30	7·0
4. Had a second thread underneath, and a vessel from the superior internal articular artery.	F.	R.	0·80	0·10	26·0
5. There was a thin synovial reflection like a rudimentary septum, behind or posterior to the ligament. This was fellow limb of preceding.	F.	L.	0·70	0·10	22·0
6. Was so thin I did not test its breaking strain.	M.	L.	0·95	—	—
7. Had no trace of any vessel, and was composed of two threads, one of which was inserted 0.2 inch below the femoral notch; the other was attached to the outer condyle.	F.	R.	0·55	—	5·0
8. Broke at femoral attachment in testing the strain.	M.	R.	0·45	—	5·0
9. Broke at femoral attachment.	M.	L.	0·60	—	10·0
10. Slight trace of a vessel near the marsupium.	F.	R.	0·95	—	3·50
11. There was a well-formed hood on the internal condyle; the ligament broke from its femoral attachment, and a slip went from about the middle of this ligament to the anterior crucial ligament; a second slip went from the femoral attachment to a fatty mass on the anterior crucial ligament.	M.	L.	1·10	—	11·5
12. This ligament existed in a subject with very long lower limbs.	F.	R.	0·50	0·15	14·0
13. The weight was not very accurate in this case.	F.	L.	1·00	0·20	5·0
14. Carried several vessels, though only the diameter of a coarse thread, and broke from its femoral attachment.	F.	R.	0·55	—	7·0
15. Was a double thread, and had no trace of vessels.	M.	R.	0·65	—	—
16. Had a second band, of the same size and thickness as the ligament itself, going from its femoral attachment to the anterior crucial ligament. *The joint could only be flexed to a limited extent until both the accessory band and ligament were burst through.* Fig. 1.	F.	L.	0·60	—	—
17. Was a slender thread.	M.	L.	1·00	—	
18. Contained a vessel, and a fatty lobe in the middle.	M.	R.	1·20	—	—
19. The fellow limb of preceding; both had traces of hoods on their internal condyles.	M.	L.	1·25	—	—

Class IV.—Ligament was absent.	Sex.	Side.
1. It probably existed at some time during life. There were slight traces of a hood on the internal condyle. The fellow limb of No. 8, Class III.	M.	L.
2. Some remains at the marsupium as if it had existed.	M.	R.
3. Some remains at the marsupium; also traces of rheumatic disease.	M.	L.

Fig. 3. Refers to No. 9, Class II.



p = Patella.
a = Mass of fat.
b = Bursa.
t = Tibia.
f = Femur.
x = Anterior crucial ligament.
m = Ligt. mucosum.

Notes on the Comparative Anatomy of the Ligament.

Siredon maculatum. The extensor tendon arose from the front of the femur, and the ligament existed behind it as a lamina of synovial membrane.

Rana mugiens. The synovial membrane was separate from the rectus tendon, so that on cutting the latter across and throwing it down the joint was unopened. On opening the joint the ligament was seen beneath the tendon that traverses the joint, and was connected with the semilunar cartilage.

Tejus teguixin. The ligament consisted of a band connecting the internal part of the femoral notch with the anterior portion of the internal semilunar cartilage.

Iguana rhinolophis. Same as in preceding case; was a strong, fibrous band, quite separate from the crucial ligaments.

Ameiva lineolata. Same as before; was a flat membrane. A sort of horizontal septum.

Amphibolurus barbatus. Same as before; the internal semi-lunar cartilage was attached to the internal condyle by a band of synovial membrane.

Chameleo vulgaris. I examined two specimens of this reptile, in both of which the ligament was absent.

Moloch horridus. Same as in *Amphibolurus barbatus.*

Ecphymotes obtusirostris. A mere thread, attached like the preceding ligament; there was a second band of some width going to the internal condyle.

Crocodilus biporcatus. This was a very young specimen, the ligament existed as in the lizards.

Tatusia hirsuta. The ligament formed a complete septum, was T-shaped, and formed the sheath of the extensor tendon.

Sheep. Formed a complete septum, and was roofed in on the external side by the synovial membrane which formed the sheath of the extensor tendon; there were vessels on its surface from the external articular and azygos arteries.

Lutra vulgaris. The ligament was T-shaped, and formed a complete septum.

Nasua narica. It formed a complete septum, the synovial membrane being reflected over the marsupium, thus roofing in the cavity.

Canis familaris var. Was composed of several threads containing fat, and a vessel from the superior internal articular artery.

Ursus lasiotus. Was loaded with fat; did not form a septum.

Ursus Himalayanus. It formed a complete septum, and at the posterior border was traversed by a large branch from the azygos articular artery.

Presbytes comatus. The ligament was absent.

Cercopithecus griseo-viridis. It existed as a coarse thread.

Cercopithecus mona. In the right limb the ligament was a mere thread, in the left limb it was double, one thread being attached to the external condyle.

In conclusion I wish to draw attention to some points which anatomists have, I think, stated wrongly, or passed over without notice.

1. Luschka says, "That only exceptionally does it form in man a membranous sagittal septum." Now, it appears to me that the complete septum is somewhat more than an exception, seeing that nearly

one-fourth (22½ per cent.) of my cases deserved that title; and if the number of partial septa be taken into account, I think the tendency of the ligament in man is quite as much towards the septate condition as the filiform.

2. Hyrtl remarks, "It appears knotty from fat, or it includes a fibrous string which conveys blood-vessels to the patella; these seem to fill vacant spaces in the joint." With the first part of this statement I entirely disagree, for, in those specimens I examined, the vessels did not approach the patella at all, but went rather to the femoral attachment of the ligament (*i. e.*, the intercondyloid portion of the femur); whether they nourished that portion of the bone or not, I am not prepared to state: with the latter part of his statement I feel inclined to concur, for, as far as I can judge, the function of the ligamentum mucosum is to adjust the fatty lobe at the marsupium patellare, to fill the various vacant spaces in the joint, in the different positions between complete flexion and extension.

3. In several of the lower animals I observed that when the ligament formed a complete septum, it was continuous with the synovial membrane forming the sheath of the extensor communis digitorum, which passes across the external side of the joint, and at the same time roofs in the outer division of the joint. In some human joints I found bands going from the marsupium to the external reflection of the synovial membrane.

4. On two separate occasions, in man I observed an additional ligament going from the marsupium to the hood that is often found on the internal condyle; in *Ecphymotes obtusirostris* this ligament existed as a strong fibrous band.

5. With regard to the development of this ligament nothing is as yet known; it is a point which would probably clear up its morphological nature, and throw light on the vexed question, "the origin of synovial membrane," on which much has been written, and of which the best modern exposition is that published this year in Leyden, by J. G. Van der Sluijs (Over den Bouw van het Synoviaalvlies, Leiden, P. Somerwil, 1875).

XXX.—On Some Forms of the Ligamentum Pterygo-spinosum. By A. Macalister, M. B., Professor of Comparative Anatomy, Dublin University. (With Plates 19 and 20).

[Read April 27, 1875].

The bony arch stretching from the outer pterygoid plate to the spina angularis of the sphenoid bone has been described by many authors; Dieterich,* Gruber, Barkow as well as the manual writers have noticed its existence and some of its forms. Its most common condition in man as the ligamentum pterygo-spinosum has been shown by Civinini† and its comparative anatomy as the representative of the canal or foramen present in the ecto-pterygoid plate in Rodents has been abundantly referred to by these writers.

The object of the present paper is to catalogue the very varying forms of this ligament found in the skulls in the collection of the Dublin University.

The ligamentum pterygo-spinosum is an upward and forward elongation of the fascial fold which forms the internal lateral ligament of the mandible, and usually appears as a flat band, wider at its pterygoid than at its spinous attachment, but variable in shape, lying usually internal to the Arteria meningea media, external to the tensor palati, which often takes an additional origin from it; posteriorly and internally it is related to the fibrous capsule of the Eustachian tube, to which it is often tightly bound.

Beside the simple ligamentum pterygo-spinosum, there exists very often a second band connected with it at its pterygoid end (Pl. 20, fig. 14 *a*), but inserted external to the foramen spinosum into a small spur. This little process is very frequently present as a sharp tooth on the outside of the oval and spinous holes (figs. 1, 2 *a*), and the band attached to it is much shorter, higher up, and bounds a narrower archway; to this second ligament the name ligamentum pterygo-spinosum accessorium is applicable, it roofs over the nervus temporalis profundus and n. massetericus (fig. 14 *t′ t″*). This ligament may be separate from the first named, or joined to it at its pterygoid end, or for most of its extent, and only separated where it is pierced by the middle meningeal artery and some nerve filaments.

Of the bony arrangements coexisting with these ligaments there are the following, and I have appended thereto the proportional frequency of their occurrence out of 144 skulls.

1st. The existence of the ligament with no ossified tooth on the external pterygoid plate. This occurred in fifteen of the skulls on both sides, and in four on one side only. In one of these the nervus

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* Dieterich, Beschreibung einiger abnormitäten des Menschen-schädels. Basel, 1842, p. 9.

† Schmidt's Jahrbücher, 1853.

spinosus of Luschka (Müller's Archiv., 1853), traversed a well-marked groove from the oval to the spinous foramen, and the tip of the spina angularis was nearly separated from its base by a suture.

2nd. The presence of a tooth on the external pterygoid plate (figs. 6 *u*), as the only ossified part of the ligament; this I have seen very large, and in one negro skull (tribe unknown) from the Gold Coast, it appeared as a round tubercle near the base of the external pterygoid plate, but separate from that plate. Several instances of this tooth were coexistent with a very thin oblique lamellar septum between the oval and spinous foramina, and in one case the two foramina were not separated, while on the right side of another the oval foramen communicated with the pterygo-sphenoidal fissure. The spinous foramen in another specimen was in the line of the spheno-petrosal suture. Cases of this kind occurred in twenty skulls.

3rd. Cases of the presence of a second distinct tooth on the pterygoid plate. This is noticed in Theile's Muskellehre, p. 68, where such a tooth may be below the primary one, is always flatter and weaker, and rarely has a ridge like the prominent rib on the inside of the ectopterygoid plate, which crosses the upper part of the pterygoid fossa to strengthen the primary tooth; sometimes a second accessory tooth higher than the primary one is present, but this usually coexists with the spur to be described below (No. 5), and is for the accessory ligament. The lower tooth is for the attachment of the external pterygoid muscle. Cases of the existence of this second tooth existed in nine skulls.

4th. The coexistence with the fore-mentioned tooth or teeth of a forward-directed spur on the spina angularis sphenoidalis was noticed in eighteen skulls: sometimes this is of very large size, projecting towards the pterygoid tooth, but always separated by an interspace (figs. 1, 2, 13 *p*). This very often existed with a double pterygoid tooth, and in one instance where it was present there was no pterygoid tooth: in one case there was no spina angularis on the sphenoid, but a process sundered from the anterior and internal end of the vaginal ridge (spina petrosa) took its place. This spina petrosa is not rare, either as an angle of the vaginal ridge or as an independent spur, and it often contributes with the spina angularis to give origin to the internal lateral ligament of the lower jaw.

5th. The existence of a spina accessoria external to the foramen ovale, and separated from the spina angularis by the foramen spinosum, has been before referred to as giving attachment to the ligamentum accessorium pterygo-spinosum (figs. 1, 2, 9 *a*), and it may be present and distinct even though the two ligaments are united. This is a very frequently present spine, as it exists in forty-one skulls. I have even found this present in the skull of a three-year-old child. In some of these it was only present as a minute rudiment, but in others it was long, and formed nearly a loop with a long pterygoid tooth. In a Chinook skull this coexisted with a fine lamellary septum between the foramina ovale and spinosum. In a Mandingo skull it coexisted with a strong spina petrosa, taking the place of the spina angularis. In a Melanesian skull from Chatham Island it coexisted with a fossa pterygoidea externa, protected by a strong processus pterygoideus accessorius (the same fossa I have seen in the skull of a negro, and I have referred to it elsewhere) (fig. 12 A).

6th. This spina sphenoidalis accessoria may coexist with a forward directed tooth on the spina angularis, and this exists in thirteen skulls. In one of these, the angular tooth is pierced externally by the middle meningeal artery. These two spurs often rise as sharp peaks, one in front and the other behind the foramen spinosum, so as to give the appearance as if the foramen bored through the spine; this occurs in several crania, among others in one Australian, one from Circassia, and one found embedded in plaster, at Sinai. Sometimes the apices of the two spines are joined by a bridge (that is, the band of union which forms the posterior part of the connexion between the ligamentum pterygo-spinosum and the accessory ligament [when these are united], becomes ossified), and then there are two external outlets for the foramen spinosum, an outer (larger and transmitting the artery) and an inner, smaller, and usually transmitting the nervus spinosus (fig. 7 *a'*). This may coexist with a double tooth on the ecto-pterygoid process, but if so the second tooth is generally the lower, muscular, one.

7th. Cases of the formation of a complete bony bridge are not rare. Professor Gruber assigns a frequency of once in thirteen to fourteen skulls. In our collection we have nine in which such a bridge occurs on both sides, five in which it is present on one side. Thus our proportion is, that a bilateral bridge exists in one in sixteen, a unilateral or bilateral, once in 9.5 cases.

Two forms of this bridge exist which should not be confounded:—1st, ossification of the true ligamentum pterygo-spinosum. This is either simple, forming a large wide arch (not a common form) (fig. 9 *l p*), or compound, coexisting with an ossified ligamentum pterygo-spinosum accessorium. This latter form is the commonest, and, as the two ligaments are usually united for a good part of their extent, so the bony arch is simple, wide, and shows its double nature by having two piers at its hinder end, one continuous with the spina accessoria, one with the true spina angularis (figs. 8, 11 *o'*). The other form is a simple ossification of the ligamentum accessorium which then forms a closely adpressed arch, only bridging over the temporal and masseteric nerve. (figs. 10, 13 *a u*). This I have seen well marked in an Esquimaux skull with no spina angularis, and in a Chinook skull, as well as in several Irish crania.

The ossification of the true pterygo-spinous ligament never takes place autogenously. The forward end ossifies by an extension into it of the bony matter of the external pterygoid process, while the hinder end ossifies as an offshoot from the spina angularis; hence where the two bony growths coalesce there is, in nearly every case, a suture, which I have very seldom seen obliterated, and which is sometimes dentated (fig. 9 *x*). This is often the case in the ligamentum accessorium also (fig. 10 *x*), but here complete ossification and obliteration of the suture at the point of junction is much commoner, so that the arch becomes simple, solid (fig. 13).

A form of spurious arcuation may be produced by the elongation and convergence of the two ecto-pterygoid teeth, which may loop towards each other in an arched form, and may even touch, leaving thus a round hole in the external pterygoid plate (figs. 2, 4 *n*). This when present transmits an anomalous branch of the internal maxillary artery.

The whole trunk of the internal maxillary, in a not uncommon anomalous course under the external pterygoid muscle, either pierces below, or through, or under the ligament of Civinini, so that when this band is ossified, it is not uncommon to find the whole trunk of the artery passing through the loops of the bony bridge. Such an arrangement is the exact repetition of the course of the artery in Rodents and many other mammalian orders; indeed this seems the only assignable use for the ligament, to protect the artery from the pressure of the pterygoid muscles. In Henle-Krause's Handbuch der Gefässlehre des Menschen, p. 243, Professor Krause describes the anomalous internal maxillary as trasversing sometimes a hole in the lamina lateralis processi pterygoidi ossis sphenoidei (external pterygoid plate), and speaks of this being analogous to the condition in the rabbit. The hole referred to is the arch of the ligament; for the trunk internal maxillary artery never passes through any hole in the outer pterygoid plate proper.

In a Mandingo skull, the spina angularis is double, half formed of the squamosal element of the anterior lip of the glenoid cavity, and half of the sphenoid, the spheno-squamosal suture crossing the summit of the process, and this coexists with a foramen spinosum in the spheno-petrosal suture. In another skull the tooth on the pterygoid plate is a tooth on the outside, not on the hinder margin of the plate.

XXXI.—On a Malformed Corona of Echinus esculentus. By H. W. Mackintosh, B. A. (With Plates 21 and 22).

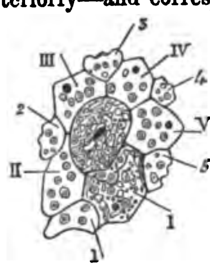
[Read May 10, 1875.]

The remarkable specimen which is described in the present communication has lain for many years in the Museum of the Dublin University, having been, as I am informed by Professor Dr. Perceval Wright, dredged up by the late Dr. Ball off the coast of Youghal.

I had often noticed it in the course of my museum studies, on account of the prominent pouch which the actinal (oral) aspect presents, but had not bestowed more than a casual inspection on it till recently, when its many peculiarities so forced themselves on my attention, that I requested and obtained permission of Professor Dr. Macalister, the present Director of the Museum, to place a short description of it on record.

In describing the present specimen I shall not attempt anything like a detailed notice of all its peculiarities. Such a proceeding would be but of little value or interest, and a mere abstract description of such a shell would convey but little idea to the mind; hence I prefer relying on the drawings* for this purpose, and will only indicate here the chief features of interest.

For purposes of convenience the madreporic plate—placed posteriorly—and corresponding interambulacrum will be numbered I, the next genital plate on the left, and its interambulacrum will be II, and so on from left to right; the ocular plate and ambulacrum on the immediate left of the madreporic, will be 1, the next on its left 2, and so on in the same order; and, since each area has a double series of plates, these will be called I *a*, I *b*, &c., or 1 *a*, 1 *b*, &c., respectively. I adopt this method simply for convenience and not with any reference to the views put forward by Professors A. Agassiz or Lovén, as to the position of the madreporic plate.



Looked at as a whole, the corona is seen to be considerably flattened on the madreporic side, which is produced on the actinal surface into a sort of boss or pouch (Plate 21, fig. 2). The mouth is eccentric, displaced to the lower left-hand side; the auricles are normal. In the abactinal system, plate I (madreporic), is unsymmetrical, being prolonged at the upper left-hand corner, and has but little of the character-

* Which have been all taken under the *camera lucida*. As the outlines of the plates are the most striking part of the corona, I have drawn them as accurately as I could, and have therefore laid down the tubercles almost orthographically.

istic granulation; plate II. is very much elongated anteroposteriorly, and the orifice for the genital duct has disappeared; plate III. presents the reverse condition, being broader than deep, and has its genital aperture; plates IV. and V. are but slightly altered. The ocular plates are scarcely changed in form, with the exception of plate 1, which is considerably elongated at the lower left-hand corner. The anal system corresponds in outline to the abactinal, being drawn out from before backwards.

In the corona the alterations are mainly confined to ambulacrals 1 and 2, and to the corresponding interradia, and of these, interambulacrum I *a* is scarcely changed, being merely curved to the right a little more than usual; I *b* is a good deal altered, its fourth plate (from the top) seems to be made up of two fused together; and the twelfth and succeeding plates are very much elongated towards the left side, and seem to include the greater part of the actinal boss. Ambulacrum 1 seems to be only represented by the short series of pores seen in Plate 22, fig. 4, which terminates almost at the summit of the boss, and the perforations of which have no very definite arrangement. This ambulacral area is thus altogether included in I *b*. The next ambulacrum is a curious one. It begins normally, both in arrangement and position, but soon bifurcates, one division going up to the abactinal system to form ambulacrum 2, of which 2 *b* is perfectly unaltered, but 2 *a* is remarkable for the exceedingly scattered disposition of its pores (Plate 21, fig. 2), some of which are placed well within interambulacrum II *b*, whilst others are situated in the middle line of their own radium. The other half of this ambulacrum runs up to a short distance above the ambitus (equator of the corona), where it abruptly terminates, thus circumscribing interambulacrum II., which, ending in a point a little below the ambitus, fails to reach the actinal opening, and assumes a striking petaloid appearance. There are thus but four ambulacral areas reaching the abactinal system, No. 1 being deficient, and its place occupied by the remarkable congeries of plates shown in the figures.

The dimensions of the corona are as follows :—

Round the ambitus, ...	15 inches.
Dextro-sinistral circumference, ...	$13\frac{3}{8}$,,
Antero-posterior circumference, ...	13 ,,
Depth (from abactinal to actinal orifice), . .	$3\frac{5}{16}$,,

As regards the cause of this curious malformation it is difficult to speak absolutely. The altered side of the corona, though presenting more or less of an undulating appearance, has no sharp depressions such as might be caused by fracture and repair; if this has taken place it has been unusually evenly done, for it is seldom that the calcareous parts of Echinoids are repaired without showing very manifest tokens of the change. The flattening of the altered side, and the presence of the actinal boss, suggest the idea that the lateral growth of the test was limited by its surroundings, and had to take place in a downward direction—a supposition which perhaps would be strengthened by the absence of ambulacra on the flattened side. I am free to confess, however, that this solution is not satisfactory, for it would be a matter of no little difficulty to arrange the surroundings so as to produce the given result, and hence I am fain to keep clear of the cloud-begirt regions of hypothesis, and limit myself to the simple record of facts.

Malformed specimens of Echini have been described by the following:—

Philippi, "Weigmann's Archiv fur Naturgeschichte, 1837." I have not been able to consult this paper, as the volume of this Archiv for 1837 is not in any of the Dublin libraries.

Kinahan and Du Noyer, "Proceedings of the Dublin Natural History Society," vol. ii., 1857. The specimen seems to combine the pores and tubercles of *Strongylocentrotus lividus*, with the actinal system of *Echinus esculentus*.

T. H. Stewart, "Annals and Magazine of Natural History, 3rd series, Vol. v., 1860." The malformation is chiefly in the abactinal system, the corona being but slightly altered.

Dönitz, "Reichert und Du Bois Reymond's Archiv, 1866." The malformation consists in the almost total disappearance of one of the five interambulacra, and a corresponding change in shape of the corona.

XXXII.—REMARKS ON THE STRUCTURE OF THE LEAVES OF CERTAIN CONIFERÆ. By W. R. M'NAB, M. D., Edinburgh, Professor of Botany, Royal College of Science for Ireland. (With Plate 23.)

[Read June 14, 1875.]

IN a Thesis which was presented to the Faculty of Science, Paris, and published last year, Dr. C. E. Bertrand describes the comparative anatomy of the stems and leaves of the Gnetaceæ and Coniferæ. In his descriptions Bertrand gives anatomical characters by which sub-genera may be readily separated, and also gives tables by which to identify the species. Believing that, in one or two respects, Bertrand has come to erroneous conclusions, I determined to re-investigate certain points which I considered of importance. In doing so I had the great advantage of having access to the collection of Coniferæ at the Royal Botanic Garden, Edinburgh, where most of the rare and valuable North American species are carefully cultivated. We are certainly much indebted to Bertrand for pointing out that valuable characters can be got by anatomical investigation of the leaves of Pines. To the nurseryman who has chiefly to do with small plants without cones, any good method of determining species by the foliage must be welcome. While, however, I acknowledge the value of such anatomical characters, I do not think we can place implicit confidence in them alone; but that, when taken along with other characters, they are of the highest value. It is chiefly by making transverse sections of the leaf that the investigation is to be carried on. Very thin slices are to be taken from the middle of the leaf, care being taken to have the sections in the proper plane. All the sections I have examined were placed at once in dilute glycerine; and, in nearly all cases, the perfectly fresh leaf was used. The chief points to observe in the sections are:—1st, the nature of the fibro-vascular bundles or midrib; 2nd, the sheath of the fibro-vascular bundles; 3rd, the resin canal or canals; 4th, the thickened cells or hypoderma belonging to the ground-tissue, and placed below the epidermis, but not belonging to it; 5th, the parenchyma of the ground-tissue; 6th, the epidermis, with its cuticle; and 7th, the arrangement of the stomata; this last, however, requiring the examination of the upper and under surfaces of the leaf in addition.

My attention was first directed to Bertrand's sub-genus Tsuga, which includes—*Pinus Pattoniana, canadensis, Mertensiana, &c.* I think it is best to follow Parlatore in his definition of the genus Pinus; but I would limit Parlatore's section Tsuga, and use it in the restricted sense in which Carrière and Bertrand employ it. In Parlatore's Coniferæ (De Candolle Prod., vol. xvi., pars 2), the section VI. Tsuga Endl. Parl. is used to include:—Tsuga Carr., Keteleeria Carr., and Pseudotsuga, Carr. *Pinus Douglasii* belongs to Carrière's Pseudotsuga, and *Pinus Fortunei* to his Keteleeria. Both *P. Douglasii* and *P. Fortunei* must be placed in Carrière's Pseudotsuga.

The section Tsuga is well characterised by the presence of a single median resin canal, which is placed below the single central fibro-vascular bundle forming the midrib; by the flattened leaves bifariously placed; and lastly, by the presence of well marked cushions supporting the leaves.

Five species, as described by Parlatore, belong to the restricted section Tsuga, viz.:—

106. P. Tsuga Ant.
107. P. canadensis Linn.
108. P. Mertensiana Bougard.
109. P. dumosa Don.
110. B. Pattoniana Parl.

To this I have one to add, viz., P. Hookeriana, the Abies Hookeriana of A. Murray.

Bertrand only distinguishes four species by anatomical characters, and gives the following synoptic table of these characters:—

Stomata on the upper surface of the leaf; Margin entire; no hypoderma,	. .	P. HOOKERIANA.
No stomata on the upper surface of the leaf; Margin of leaf serrulate; hypoderma,	.	P. CANADENSIS.
Margin entire, { No hypoderma,	. .	P. BRUNONIANA.
Margin entire, { Hypoderma,	. .	P. SIEBOLDII.

Bertrand further gives the following table of the synonomy and distribution of the species:—

Picea (Tsuga) Hookeriana Carr., Northern California.
Syn. Abies Pattoni Jeff. A. Hookerii Hort. A. Williamsonii Newbury.
Picea (Tsuga) canadensis Link. (T. Mertensiana does not differ anatomically from T. canadensis). Rocky Mountains.
Syn. Abies canadensis Mich. Pinus Americana Du Roi. P. canadensis Linn.
Picea (Tsuga) Brunoniana Wall. Southern China.
Syn. Abies dumosa Loudon. A. cedroides Griff. Micropeuce Brunoniana Spach. P. decidua. Wall.
Picea (Tsuga) Sieboldii Carr. Japan.
Syn. Pinus Tsuga Ant.

From my examination of the species of the section Tsuga, I find that Hookeriana and Pattoniana are distinct; but I can refer neither of them to Bertrand's Hookeriana. Probably his Hookeriana is our

Pattoniana; but in all specimens that have come under my notice the hypoderm is developed, while Bertrand distinctly says, "Pas d'hypoderm." Then the specimens of canadensis and Mertensiana examined by me are quite distinct. In this case I think that Bertrand has described Mertensiana for canadensis. Lastly, in his description of Brunoniana and Sieboldii we are slightly at variance.

The forms about which the greatest confusion has existed are Hookeriana and Pattoniana. Both are, at first sight, very similar in habit and in appearance, while their cones are also exceedingly close. They are, however, readily separated by the structure of the leaf. In Hookeriana the resin canal is separated from the fibro-vascular bundles by a few parenchymatous cells, containing chlorophyll—a character which does not occur in any of the other species. The leaf is also thicker, more tetragonous than Pattoniana; the margins of the leaf are entire, while in Pattoniana they are distinctly serrulate near the apex. Both the species, however, agree in having stomata on the upper as well as on the under surface of the leaf. In Hookeriana the hypoderm forms a nearly continuous row of cells beneath the whole epidermis, giving such an appearance as might almost be produced if the epidermis consisted of a double instead of a single layer of cells.

Taking all the characters, I would give the following table by which to separate the different species:—

I. Young shoots hairy.

A. Resin canal separated from the sheath of the fibro-vascular bundles by one or two layers of large chlorophyll-bearing cells; leaf flatly tetragonous, the hypoderma nearly continuous around the whole leaf; stomata on both surfaces. . . . . . . 1. T. HOOKERIANA.

B. Resin canal in contact with sheath of fibro-vascular bundles.

1. Stomata on both sides of leaf; hypoderma well developed. . 2. T. PATTONIANA.

2. Stomata on under surface of leaf only.

a. No hypoderma; margin of leaf rough; apex obtuse. . 3. T. CANADENSIS.

b. Hypoderma at margins of leaf, and above midrib; margin of leaf ciliate; apex obtuse. . 4. T. MERTENSIANA.

e. Hypoderma at margins of leaf, and at each side of the resin canal; margins of leaf slightly reflexed; serrulate; apex obtuse, ... 5. T. Brunoniana.

II. Young shoots glabrous; hypoderma at margins of leaf only; margin of leaf entire; apex emarginate, sometimes obtuse; stomata on under surface of leaf only. . . . . 6. T. Sieboldii.

1. Pinus (Tsuga) Hookeriana.

Abies Hookeriana A. Murray, Edinburgh New Philosoph. Journal, 1855, p. 289.

Tsuga Hookeriana Carr.? not of Bertrand.

Shoots hairy; leaves four to seven lines in length, irregularly bifarious; margin entire; apex obtuse; two sides of leaf similar dark green, with four to six rows of stomata on each side of the middle line. Plate 23, fig. 1.

2. Pinus (Tsuga) Pattoniana.

Abies Pattoniana Jeffr. Oregon Bot. Exped. 3.

Shoots hairy; leaves six to nine lines long, irregularly bifarious; margin denticulate near the obtuse apex; upper side yellowish green, with from two to four rows of stomata on each side of the slightly marked central furrow, beneath with six to seven rows of stomata on each side of the middle line. Plate 23, fig. 2.

The forms cultivated in the Edinburgh Botanic Garden, under the names of Abies Parryana and Abies Hanburyana, cannot be separated by any characters from P. Pattoniana. This is not Pinus Pattoniana of Parlatore, as he includes both this species and P. Hookeriana.

3. Pinus (Tsuga) canadensis Linn. Parlatore.

Shoots hairy; leaves six to nine lines long in two rows; margins rough; apex obtuse; upper side dark green, with a central furrow, beneath with eight or nine rows of stomata on each side of the prominent resin canal. Plate 23, fig. 3.

4. Pinus (Tsuga) Mertensiana Bougard. Parlatore.

Shoots hairy; leaves four to seven lines long in two rows; margins ciliate; apex obtuse; upper side dark green, with a central furrow, beneath with eight or nine rows of stomata on each side of the middle line, where the hypoderm is developed. Plate 23, fig. 4.

The forms cultivated in the Edinburgh Botanic Gardens, under the names of Abies Albertiana, Abies Bridgesii, and Abies Williamsonii, cannot be separated by any characters from P. Mertensiana.

Parlatore gives A. Williamsonii as a synonym of his P. Pattoniana, while Bertrand gives Williamsonii as a synonym of his T. Hookeriana.

5. Pinus (Tsuga) Brunoniana Wall.

Pinus dumosa Don. Parlatore.

Shoots hairy; leaves twelve to fourteen lines long in two rows; deciduous; margins slightly reflexed; serrulate; apex obtuse; upper side grass green, with a central furrow, beneath with a band of nine or ten rows of stomata placed close to each side of the central carina. Plate 23, fig. 5.

6. Pinus (Tsuga) Sieboldii Carr.

Pinus Tsuga Ant. Parlatore.

Shoots glabrous; leaves eight to ten lines long in two rows; margin entire; apex emarginate, sometimes acute; upper side dark green, with a central furrow, beneath with a band of six to eight rows of stomata on each side of the middle line. Plate 23, fig. 6.

In conclusion, I have to tender my best thanks to Dr. Moore, Glasnevin, for kindly furnishing me with specimens from Glasnevin Gardens; while to my father I am chiefly indebted, as he furnished me with specimens of all the forms cultivated in the Royal Botanic Garden, Edinburgh.

XXXIII.—On Two Dissimilar Forms of Peritypylic Pouches. By Alexander Macalister, M.B., Professor of Comparative Anatomy, Dublin University. (With Plate 24.)

[Read June 14, 1875.]

In a paper published in Virchow's Archiv., 1874, Band. 60, p. 66, Prof. Waldeyer of Breslau gives a resumé of all the cases of post-abdominal pouches of which he has found records, and from these data proceeds to classify these pouches according to their anatomical position, and to suggest the probable cause of the formation of each species. His experience agrees with that of every practical anatomist, that the neighbourhood of the cæcum is that which is most fertile in irregularities, as he catalogues four species which occur in this locality.

Having seen a very large number of these pouches, I was early led to believe that, although it is useful, for convenience, to classify these, yet scarcely two of these peritypylic pouches are alike. This is what one might expect from a few moments' thought on the remarkable and variable changes to which this region is exposed in the course of the development and descent of the cæcum, and hence almost every case that occurs has its own features of interest.

In the present volume of the* Proceedings of this Academy one variety of pouch was described by Mr. Leeper, under the name of *recessus retrocæcalis*, a pouch which, though belonging to a genus of fossæ similar to others described elsewhere, yet had strongly marked individual features of its own. A case resembling this in some features occurred in an old emaciated female subject dissected at the end of the last session in the Anatomy room of the Dublin University. This subject showed a faint superior ilio-cæcal pouch, whose floor was formed by the layer of peritoneum at the inferior and left end of the root of the mesentery, which was attached to the anterior surface of the psoas muscle. There was no inferior ilio-cæcal fossa, and the mesenteriolum was slender, not bounding any ilio-cæcal recess either above or below it, nor was there a trace of a sub-cæcal fossa. The descending colon was very long, and, as is always the case under such circumstances, the end of the cæcum was pushed well forwards, lying on the anterior wall of the abdomen, the fundus of the cæcum being well turned forwards, and the peritoneal covering of this part of the large intestine was exceedingly imperfect, the serous membrane passing as a tense lamina from the sides of the cæcum to the sides of the abdominal wall. The ascending colon on the level of the crest of the ilium was displaced backwards in a knuckle-like fold, to such a depth that the middle part was quite buried in a backwards and inwards-reaching sac.

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* *Antea*, p. 79.

On pulling this out, a large pouch was displayed, burrowing behind the psoas muscle as far inwards as the vertebral column opposite the transverse process of the fifth lumbar vertebra, having a strong ilio-lumbar ligament above it, and being crossed at its upper part posteriorly by the ilio-hypogastric nerve, and a little lower by the ilio-inguinal. A separate slip of the psoas muscle from the transverse process of the fifth lumbar vertebra projected into the fundus of the sac. The mouth of this fossa looked upwards, and a little forwards and outwards, and was bounded in part by a crescentic fold of iliac fascia from the anterior surface of the psoas magnus (there was no psoas parvus), passing outwards to the front of the iliacus. So deep was this pouch, that the index finger introduced into it could be imbedded to the base of the second joint, and could touch the back of the common iliac artery at its bifurcation behind the psoas. Fully three and a half inches of the colon were sunk into this recess, and held there by the reflection of peritoneum from the ascending lumbar mesocolon outwards to the wall of the fossa. The pouch had a distinct flooring of iliac fascia.

Co-existing in this subject was a good large intersigmoid pouch with, as usual, no fascial relations, but a crescentic fold of fascia formed a shallow retrosigmoid fossa like that described by Leeper. There was a very strong and large cysto-hepato-colic ligament. Fully five inches of large intestine stretched from the lower lip of the pouch to the fundus of the cæcum, and at the inner side of the pouch the peritoneum was raised and rendered prominent directly internal to the involuted portion of the colon, by the prominent inferior angle of the duodenum.

In comparing this case with the already described instances of cæcal fossæ, it will be seen to resemble most closely the three cases recorded by A. Biesiadecki of Cracow, in the Untersuchungen aus dem Pathologische-Anatomische Institut in Krakau, Wien, 1872. The fossæ, which this author groups under the name fossa iliaco-subfascialis, had this in common with it, that they were bounded by a prominent fold of the iliac fascia, that they were between the psoas and iliacus, that the iliacus muscle was more or less behind it; his cases were also distinctly beneath the lower edge of the iliac fascia, which was strengthened by the fibres of the psoas parvus.* A case of cæcal fossa is described by Huschke, in which a fold of iliac fascia is referred to; but this is by no means identical with either Leeper's pouch or the one described above, as Huschke's is circumstanced very differently, for this author describes having found, by an exaggeration of the normal descent of the intestine, a falciform fold formed by the peritoneum and the fascia iliaca, very prominent, upwards and forwards, form-

* Even when this muscle does not exist as such, a strong band of fibrous tissue strengthens the iliac fascia and passes outwards across the iliacus at its site of insertion, while a slip of strengthened aponeurosis lies in the situation of its tendon on the inner side of the psoas magnus. These should be regarded as rudimental organs.

ing a sort of bed for the cæcum (Huschke's Eingeweidelehre, p. 79; Jourdan's Trans. 1845, p. 90); here the fold is produced by the descent of the cæcum, and the intestine accurately fits the fossa. In speaking also of the peritoneal investment of the cæcum, he says, that the beginning of the right colon has often a peritoneal ligament attached (right colic ligament of Hensing,) which raises itself from the right iliacus muscle, and often forms a fossa of which the opening receives the colon; this he calls the cæcal ligament. The marks whereby this is distinguished are its accurately corresponding to the cæcum, and being formed by that intestine, and bounded externally by Hensing's* ligament.

Waldeyer † cites a case of the existence of what he names a fossa cæcalis; but it is different from either Huschke's, Leeper's, or mine, and also received the end of the cæcum. It occurred in a girl who died of acute Endocarditis; its right boundary was Hensing's ligament (Huschke's cæcal ligament); its left fold went to the angle of fusion of both plicæ which bound the ilio-cæcal recess. We will have more occasion to notice this instance presently. Langer ‡ has also described an instance in a young soldier which corresponds closely to that given by Waldeyer, and which also corresponded to the fundus of the well-descended cæcum; but like the former case there is no record of a fold of iliac fascia as related to the sac, although both Langer and Waldeyer were acquainted with Huschke's description. Treitz § notices cases likewise of its occurrence in children and young persons, its occurrence being due to the descent of the cæcum—"durch das Herabsinken des Cöcum wird in der That manchmal das Peritoneum der Fossa iliaca etwas eingestülpt und bildet eine sehr flache, nach aufwärts sehende Tasche, in die sich das Cöcum legt."

The instance described by Leeper differs from all these in having no relation to the cæcum or to any intestine, and being a primary fold of the iliac fascia clothed by peritoneum.

My specimen is likewise peculiar in its extending inwards behind the psoas, in its lower position regarding the ilium, in its having a perfect flooring of iliac fascia, and in its co-existence with no ligament of Hensing.

The same subject had a large subsplenic fossa, and the left obturator foramen had a shallow peritoneal involution capable of receiving the tip of the middle finger, and about three quarters of an inch deep. This ran inwards and forwards under the pectineus, and lay over the obturator vessels and nerves.

The causation of these pouches in this subject is also a point of considerable interest; the old woman was a victim to tight lacing, and presented many of the pathological phenomena arising from that condition;

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* Hensing's description is in Haller's Collect. Dissert. Inauguralis Göttingen, vol. i., p. 177.

† *Loc. cit.*, p. 81.

‡ Wochenblatt der Gesellschaft der Wiener Aertze, 1862, No. 17, p. 130.

§ Hernia Retroperitonealis, Ein Beitrag zur Geschichte innerer Hernier. Prag. F. A. Credner, 1857, p. 110.

the lower ribs were bent inwards; there was a compressed stomach, a very characteristic *schnürleber* whose right end reached nearly to the crest of the ilium. This vicious habit forcing the viscera downwards evidently exaggerated, if it did not cause, the disposition of the colon to burrow behind the psoas muscle, and thus to produce this fossa. It is interesting also to note that one of Biesiadecki's cases was also a female, while in Leeper's the pouch was utterly unconnected with any cæcal relation.

The other instance was of less interest, though more complex. In an old, thin female, which happened to be on the next table in the dissecting-room to the case just cited, the cæcum had just reached the iliac fossa, and, consequently, was well covered with peritoneum, and its fundus had just begun to turn forward when its growth was arrested; hence the vermiform appendix hung inwards and a little forwards below, but not in front of the opening of the ilium. A strong ligament of Hensing passed from the cæcum to the abdominal wall, forming the outer boundary of a sub-cæcal sac, in which the fundus of the cæcum lay, and which its sharp falciform border rendered very deep and distinct. The mesenteriolum had not yet reached its usual perfect distinctness, but the appendix lay in a distinct peritoneal fold, at the bottom of the sub-cæcal fossa, whose cavity it divided into an inner and outer part, the former having a shallow digital recess from its floor under the ilium, and its separation from the outer was completed by a ridge passing from the mesenteriolum to the anterior and inferior part of the abdominal wall, as represented in the figure. The interest of this case is, that it shows a primary stage of both the sub-cæcal and inferior ilio-cæcal fossa, in which the two are confluent, for the sac in this instance is really a sub-cæcal one with an imperfect septum. A further descent of the cæcum would have been attended with an increasing prominence of the vermiform appendix, and an increasing distinctness of the mesenteriolum, then the inner fossa would form a perfect ilio-cæcal recess, while the outer would be a sub-cæcal fossa. The continued descent of the cæcum, however, would have the effect of obliterating the sub-cæcal fossa, and leaving then the ilio-cæcal alone. The resemblance between this case and that of Waldeyer is so close as to lead me to believe that they are both varieties of one species; and the comparison of these with the other cases throws a clear light on the genesis of these peculiar and often dangerous pouches.*

* Since this paper was written (June, 1875) an instance has come under my notice of a very peculiar additional variety of sub-cæcal fossa. In a male adult, aged about sixty, a narrow slit-like opening was found below and in front of the cæcum, about 1½" long, and starting below the ilium, and extending transversely; on introducing the finger it passed under and behind the cæcum, and the fundus of the pouch was found placed upwards, backwards, and outwards, on the level of the crest of the ilium. The cæcum thus lay in and bounded this fossa, in the floor of which was the vermiform appendix. The formation of such a pit was probably due to the occurrence of an adhesion between the layers of the peritoneum and the back of the cæcum, while the latter was descending; so that the intestines, in passing down, instead of separating the laminæ, as usual, left this portion behind it.

XXXIV.—Note on the Spectrum, Polarization, and Form of the Zodiacal Light; as observed in the Years 1874 and 1875. By C. E. Burton, B. A., Member of the Rodriguez Transit of Venus Expedition (British.) (With Plate 25.)

[Read June 14, 1875.]

In the year 1872, the Royal Irish Academy entrusted me with a pecuniary grant which was to be applied in defraying the cost of construction of a spectroscope, which should be specially adapted to the examination of the extremely faint spectra of the Aurora and Zodiacal Light. (*Vide* Report on a Spectroscope of the binocular form.*)

An opportunity of studying the phenomena presented by the Zodiacal Light, under more favourable circumstances than those which prevail in comparatively high latitudes, was afforded to me by my being attached to the observing party sent by the British Government to the Island of Rodriguez, situate in the South Indian Ocean.

This fact having been represented to the Royal Irish Academy, and their permission having been obtained to the employment of their instrument during my service with the Transit of Venus Expedition alluded to above, I was enabled to take advantage of several vivid displays of the Zodiacal Light which occurred while I was absent from the United Kingdom, and to obtain the results detailed in the subsequent sections of this note.

The observations will be entered in the following order:

(1.) Those indicating the projected form of the luminosity:

(2.) Spectroscopic results:

(3.) The indications of sensible polarization: under each date on which observations of the Light have been made in more than one of the above mentioned respects.

Date and Place of Observation.—1874, June 10^d, 9^h, 30^m, approximate local mean time. Lat. 32° N., Long., 14° W.

Form.—The Zodiacal Light manifested itself very distinctly as an ill-defined luminosity of an approximately triangular form, six or seven degrees in breadth at the horizon, about forty degrees in length, and inclined some fifteen degrees to a vertical circle bisecting its base.

Spectrum.—The spectroscope, on being directed to the bright central region of the luminosity, showed a broad and nearly continuous spectrum, sharply terminated on the less refrangible side, and fading gradually into complete darkness as its refrangibility increased. The limits of the spectrum seen are defined by the wave lengths

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* *Antea*, p. 42.

5680 and 4610± expressed in seventh-metres; the units employed by Professor Angström in preparing his maps of the Solar Spectrum, and adopted in this notice. Repeated impressions of the existence of a narrow bright band, situated at, or very near to, the less refrangible end of the continuous spectrum were received this evening, and the wave length of the bright band determined to be 5680. Strong suspicions were entertained that there was a darkish band to which the wave length 5360 ± 10 was assigned, by the measures taken. These suspicions were strengthened by the evidence of another and independent observer.

Date.—June 11^d, 9^h, 30^m, local mean time.

Place of Observation.—Twenty miles N.E. from Grand Canary.

Spectrum.—As on the preceding night, the central region of the Zodiacal Light yielded an almost continuous spectrum, the sensible limits of which had the wave lengths 5670 and 4640 seventh-metres, according to the measures obtained on this occasion, the first quoted being probably the more trustworthy, on account of the much more definite termination of the spectrum at its less than at its more refrangible end. No mention is made of the bright line seen last night, in the notes made on the present occasion, but a suspicion is recorded that another very narrow and extremely faint existed, the refrangibility of which was less than that of the more defined limit of the continuous spectrum. (As June 11 was the only occasion on which the second bright line was even suspected, it is not included in the accompanying representation of the Zodiacal Light Spectrum, the details of which are laid down from the mean of the measures obtained, converted into wave lengths by curves of interpolation). (Diagram 1.)

The continuous spectrum was almost interrupted by a well-marked darkish streak, to which was assigned the wave length 5379.

Polarization.—A Savart arrangement yielded traces of polarization in planes sensibly parallel to the principal axis of the Light. These traces of polarization could hardly be due to lingering twilight, the depression of the sun below the horizon being not far from 35° at the time of observation. (Diagram 1.)

Date.—June 12^d, 9^h, to 12^d, 10^h, local mean time.

Place of Observation.—Lat. 24½° N. Long. 16° W.

Spectrum.—The Zodiacal Light appeared much brighter than on June 11^d, and the lowest power of the spectroscope was employed. The spectrum was sharply terminated on the less refrangible side, and I was convinced that there was in this position a well-defined band, brighter than any other part of the spectrum, the breadth of which was estimated to be approximately equal to that of Frannhofer's group (b), as seen with the same instrument. The wave length of the bright band was determined to be 5680. The dark streak seen last night was again detected, and its position recorded by two observers independently, whose accordant measures indicate its wave length to be approximately 5355. The more refrangible end of the spectrum was extremely ill-defined, and the measures give it a wave length which is probably much too great, being that of the point where the index in the field of the eye-piece ceased to be visible, namely, 4640 seventh-metres.

Date.—June 15^d, 9$\frac{1}{2}^h$.

Place of Observation.—Lat. 13° N. Long. 17½° W.

Spectrum.—As on June 12^d, with the exception of the dark band at 5355, which was not visible, with all attention. The other details of the spectrum were visible with the usual distinctness, but the measures of the bright line were unsatisfactory, indicating its wave length to be 5720, instead of 5670, or 5680, as previously determined. This untoward discordance may have been caused by an accidental shift of the recording levers, due either to insufficient tightening of the clamp which connects them with the telescopes, or, as is more probable, judging from the tested stability of the zero, to my having mistaken the acute angle formed by the less refrangible edge of the bright line with the visible edge of the triangular pointer for the proper point of reference, namely, the apex of the triangle.

On directing the instrument to any part of the sky, except that occupied by the Milky Way, the same spectrum, *much diminished in intensity*, but otherwise recognisable, was seen as when viewing the central regions of the Zodiacal Light. The same fact was observed on many subsequent occasions in widely different localities, and with another instrument. It is, perhaps, scarcely possible to attribute this spectrum to any diffused reflection of the solar rays, for, at the hour of observation, the sun's depression below the horizon was nearly 40°, and, furthermore, the luminous appearance which yielded the spectrum its greatest brilliancy retained its form and position among the stars sensibly unchanged during the evening.

The facts mentioned in the last words of the preceding sentence, taken together with the apparently unique character of the spectrum, appear to preclude the supposition that it was due to any terrestrial aurora, the spectrum of which differs much from the Zodiacal Light spectrum, as regards both its aspect and the positions of the lines hitherto recorded, so far as they are known to me.

A suggestion made many years ago, I believe, by Sir John Herschel, to the effect that the observed extension of the Zodiacal Light from the sun indicated that the earth is probably immersed in the outer portions of a luminous haze of lenticular form, symmetrically disposed about the sun and having its principal section nearly coincident with the plane of the Ecliptic, seems to afford a possible explanation of the diffusion of the light over the whole sky, indicated by the spectroscope, and also of certain anomalies in the form of the denser portion, hereafter to be recorded.

Date.—1874, August 3^d 8^h local mean time.

Place of Observation.—H.M.S. "Shearwater." Lat. 28° 4′ S.; Long. 58° 46′ E.

Spectrum.—The bright line forming the less refrangible boundary of the visible spectrum was well observed, being much more distinct than on former occasions. This line would be more accurately described as a narrow bright band, with tolerably well-defined edges; especially that which is least refrangible. Its centre has a wave length of 5670 seventh-metres, according to the measures obtained. The dark streak at 5355± was not seen, there being barely time for the measures of the bright band, as clouds rapidly formed and obscured the Zodiacal Light. The existence of the bright band was verified by one of the ship's officers, Lieut. Pullen, R.N., who kindly gave me most efficient assistance on the occasion.

Date.—1874, August 5^d 6^h 50^m local mean time.

Place of Observation.—H.M.S. "Shearwater." Lat. 23° 45′ S.; Long. 58° 35′ E.

Spectrum.—The narrow bright streak was again seen, and its place determined, but the instrument seems to have been deranged between the observation of the Zodiacal Light and of the standard spectrum —in this case the solar spectrum. The measure has been rejected. There was a very faint and ill-terminated extension of light on the less refrangible side of the bright band, which may have been due to some remains of twilight, or to the near neighbourhood of the planet Venus, which was then very brilliant, to the region under inspection. A dark streak, apparently somewhat less refrangible than solar E, was distinctly seen. The breadth of this streak was estimated as equal to about 40 units of Angström's scale.

Date.—1874, August 10^d 7^h. Hour not noted at the time, but inserted here from recollection.

Place of Observation.—Port Louis, Mauritius.

Spectrum.—The bright band seen. The measures give 5690 seventh-metres as its wave length.

Date.—1874, August 11^d 8^h.

Place of Observation.—Port Louis, Mauritius.

Spectrum.—Measure largely in error, some slip of the clamp or record carrier having probably occurred.

Polarization.—Lieut. Neate, the chief of the Rodriguez Transit of Venus Expedition, was able to detect bands parallel to the principal axis of the luminosity, while making use of the Savart arrangement before mentioned. I could not see them, being fatigued with the previous spectroscopic work.

The bands seen indicated, according to Lieut. Neate's remarks, a slight degree of polarization in planes parallel to the axis of the Light.

Date.—1874, August 12^d. Time not noted.[1]

Place of Observation.—At sea—between Mauritius and Rodriguez.

Polarization.—With the Savart arrangement bands were visible, which were sensibly parallel to the axis of the Zodiacal Light, when at their greatest intensity; and the plane of polarization indicated seemed to lie in the same plane as the bands.

A Nicol prism confirmed the result obtained with the Savart—the mode of observation being this: the prism was rotated slowly until a faint star involved in the Zodiacal Light appeared brightest.

Date.—1874, October 10^d $7^h\pm$.

Place of Observation.—Rodriguez. Observatory House.

Spectrum.—The measures obtained give a wave length of 5655 seventh-metres for the bright line terminating the spectrum on the less refrangible side.

After October 10, the use of the recording spectroscope had to be discontinued, to my great regret; the cement used for securing the prisms having been affected by the heat and dryness of the climate, and become brittle and unsafe.

The only substitute available (pure wax) proved equally unreliable.

Date.—1875, January 2^d 8^h to 9^h 30^m, local mean time.

Place of Observation.—Curepipe, Mauritius. 1800 feet above sea level.

Spectrum.—A pocket spectroscope with one compound prism of direct vision showed a Zodiacal Light Spectrum identical with that formerly observed, except as regards the dark streak of wave length 5355, which was not detected.

Polarization.—A Nicol prism, rotated about its longer axis, produced marked variations in the intensity of the part of the Zodiacal Light viewed, upon which I kept my attention fixed during the experiment by retaining two faint stars involved in the luminous haze in the centre of the field. These stars were barely visible to the unarmed eye, but were well seen when the principal plane of the prism was at right angles to the axis of the Light.

The Savart arrangement also indicated polarized light, but much less decisively, as the Light was setting.

Form.—Herr Heidorn, of the German Expedition to Mauritius to observe the Transit of Venus, joined me in making careful observations on the general form and position of the luminosity.

We noted that the northern boundary of the Light was much better defined, and more nearly straight, than the southern; also that it passed close to a great circle described through η Tauri and ζ Pegasi. The southern boundary nearly coincided with a parabolic curve passing through α Tauri, β Ceti, and α Gruis. The luminosity extended from the W. horizon, where its breadth was about twenty-five degrees, certainly as far as the Milky Way in Taurus, its apparent width at the point of intersection being nearly three degrees. (Sketch 2.) Within this luminous region there appeared to be a distinct nucleus, the intensity of the Light increasing somewhat abruptly toward the centre from both sides, and forming a tolerably defined central cone, five or six degrees broad at the horizon, and twenty-five degrees in length. At an elevation of ten degrees from the horizon the central region of the Light appeared to exceed in intrinsic brightness every part of the Milky Way, except, perhaps, the narrow stream in Argo.

Date.—1875, February 5^d 7^h, local mean time.

Place of Observation.—Lat. 3° S. Long. 70° E.

Form of Light.—Lieutenant Neate, Chief of the Rodriguez Transit of Venus Expedition, observed a short branch or spur diverging at a small angle from the base of the principal mass of Light on the south side, as shown in Sketch 3. The spur was very faint when compared with the neighbouring luminosity, but was distinctly seen by another observer when Lieutenant Neate drew his attention to it.

Date.—1875, February, 7^d 7^h, ± local mean time.

Place of Observation.—Lat. 2° 30′ N. Long. 73° E.

Spectrum.—The pocket spectroscope used on 1875, January 2^d, showed a faint line, estimated to be near solar E. It was separated, or nearly separated, from a short continuous spectrum by a narrow dark band. The continuous spectrum faded gradually into darkness, with increasing refrangibility. This compound spectrum *varied in brightness, but did not change its character* when the instrument was swept round in a small circle parallel to the horizon at an elevation of 15° or 20°, except when it received light from any part of the Milky Way, which added its spectrum to the other, and produced confusion.

The brightness of the Zodiacal Light Spectrum was far greater when the instrument was directed toward the bright central region of the luminous cone-shaped haze than when it received light from any other part of the sky. (Sketch 4.)

Polarization.—With the Savart polariscope bands were distinctly seen, especially when the principal plane of the Nicol prism was nearly at right angles to the axis of the Zodiacal Light, and the disposition of the bands indicated that the plane of polarization was inclined about 75° to that line.

This result was confirmed by the subsequent observation with the simple Nicol prism, made independently by the same observers (Messrs. Neate and Burton).

Date.—1875, February 11.

Place of Observation.—At sea, near Trincomalee, Ceylon.

Brightness.—The Zodiacal Light began to be visible less than half an hour after sunset, and despite the neighbourhood of the crescent moon.

Date.—1875, March 31^d 8^h.

Place of Observation. Off Cape St. Vincent.

Form.—The Zodiacal Light was well seen. The upper part appeared to intersect a line passing through α and β Geminorum, about 8° or 10° south of the latter star. On this occasion the southern boundary of the luminous haze was much more definite than the northern. There was an evident nucleus or brighter region included by the outer haze. This nucleus was about 25° in length, and almost involved the Pleiades on its northern side. (See Diagram 5.)

Summary.

The observations detailed in this memoir appear to indicate :—

(1.) That the Zodiacal Light is emitted by matter partly liquid and partly solid, intermixed with gas.

(2.) That it reaches, and probably surrounds the earth, as shown by the visibility of the spectrum when viewing any part of the sky unoccupied by the Milky Way, and by the change of form seen when the observer passed from S. to N. latitudes. (Shown in the Diagrams.)

It only remains for me now to express my deep sense of the honour which the Academy have conferred upon me by committing their instrument to me for this work; as well as my regret that other avocations, while abroad and in charge of a very different species of research, together with innumerable circumstances connected with the instrument, the weather, the presence of the moon and even of Venus before inferior conjunctions, have rendered this Report much less complete than it would otherwise have been.

XXXV.—ON A READY MEANS OF DETECTING ARSENICAL COMPOUNDS.

By EDMUND W. DAVY, A. M., M. D., Professor of Forensic Medicine, Royal College of Surgeons, etc.

[Read June 14, 1875.]

THE extensive employment of certain compounds of the metal arsenic for the criminal destruction of human life, has rendered their detection under different circumstances a matter of great importance to society; and to attain this end they have long been objects of much interest to the chemist and toxicologist. Fortunately for mankind, the metal itself, as well as its combinations, have been found to be endowed with very characteristic chemical properties, and on these are based several excellent tests, by which, in the hands of the chemist or in those skilled in the detection of poisons, very minute quantities of arsenic or of its compounds can be identified with more or less facility; and the fear of such detection has acted as a great preventative against their criminal employment as poisons; for, before such means of recognising their presence were discovered, secret poisoning by arsenious acid, which is popularly known as "arsenic," was carried on to a fearful extent, a greater number, perhaps, of indivduals having been already deprived of life by that substance than by all the other known poisons put together. But now, owing to our possessing the means by which even very minute quantities of arsenical compounds can be detected with almost unerring certainty, and there having been of late years certain legal restrictions placed on the sale of arsenic, cases of homicidal poisoning by that substance have now become comparatively rare. Still, as such cases or those from accident do from time to time occur, and as different arsenical compounds are used for a number of industrial purposes, some of which are highly objectionable, endangering as they do the health, and even lives, of many individuals, it is very desirable that we should be able readily to detect those virulent substances, not only where they may occur by design or accident in different articles of food or drink, or in the bodies of those who have died from their effects, but likewise where they may exist in various manufactured products, the use of which might be attended with very serious consequences. The test which I would now propose being one of such simplicity and ease of execution that it might be performed by almost any one, will, I should hope, be found useful for the objects stated, especially to those who are not very conversant with the details of chemical manipulation. As it is a modification of Mr. Marsh's test, it is necessary for me briefly to refer to that method before describing the one I would now suggest. That gentleman's test, as is well known, is founded upon the circumstance, that nascent hydrogen in presence of certain compounds of arsenic will give rise to the formation of arseniuretted hydrogen; a gas which, being possessed of very characteristic properties, may be easily recognised, and thus very minute quantities of arsenic under different circumstances can be readily detected. This method, as proposed by its discoverer, consists in generating, in a suitable apparatus, hydrogen by the action of dilute sulphuric acid on metallic zinc, and then adding in the state of solution the arsenical compound, when arseniuretted hydrogen will be quickly generated, and a fine jet of the gas being ignited, and a cold surface placed down on the top of the flame, very characteristic spots or stains of metallic arsenic will be produced; or the gas being passed through a heated tube, it will be decomposed, and a metallic sublimate formed at a short distance beyond the heated portion. I need not refer to the apparatus recommended by Mr. Marsh for carrying out his test, as it is now so well known, nor to the modifications of it which have been subsequently proposed; and I must acknowledge that this beautiful means of detecting arsenic, owing to its great delicacy and very conclusive results in the hands of the experienced chemist, leaves but little to be desired. It, however, labours under this serious disadvantage, that the acid and the zinc which are employed in the process may one or other of them, or even both, contain more or less of arsenic as an impurity, and consequently the indications of that substance which are thus obtained, may be due not to its existing in the suspected matter or object under investigation, but to its occurring as an impurity in the materials employed in this process for its detection; and I may add that it is difficult to get in commerce the zinc and sulphuric acid required perfectly free from arsenic.

To obviate more or less this source of fallacy, several modifications of the original process of Marsh have been suggested. Thus, Fleitmann, some years ago, proposed the use of a strong solution of caustic potash, assisted by heat, instead of the acid, to act on the zinc as a means of generating the hydrogen gas, and in this way one source of arsenical contamination was avoided. It was found, however, to be too slow a means of generating hydrogen to detect arsenic in the usual way by Marsh's method. Professor Bloxam has suggested the employment of a galvanic battery for the generation of the same gas, and in this way obviates the use of zinc, and thus excludes another possible source of fallacy; but, owing to the trouble and expense attendant on the use of a galvanic battery, which for this purpose must be of some power, and the arrangement being of rather a complicated character, and still requiring sulphuric acid, it has, I believe, been but little employed. I should also add that the metal aluminium, and more recently magnesium, have been proposed as substitutes for zinc in Marsh's process or in Fleitmann's modification of it, as being less likely to be contaminated with arsenic than that metal. The modification which I would now suggest, and which, as far as I can ascertain, has not hitherto been proposed, is the employment of an amalgam of sodium and mercury as a means of generating the hydrogen required for the test: and by the use of this substance I do away with, altogether, the necessity of any acid, and I employ two metals which are not liable to arsenical contamination. As to sodium, I am not aware that arsenic has ever been pointed out as one of its impurities; and, as to its presence in mercury, that is, I believe, a circumstance of very rare occurrence; but, should it exist in that metal as an impurity, it can be readily removed from it by digesting the mercury in diluted nitric acid, and afterwards well washing it with water. The amalgam which I have found to answer very well for the detection of arsenic, consists of one part by weight of sodium to eight or ten parts of mercury, and is easily made by heating moderately in a test tube over a lamp the mercury, and then adding gradually in small pieces the sodium, taking care to keep away the face, if unprotected from the mouth of the tube, lest some of that metal in an ignited state might be spirted out during the addition of the first portions. Those metals readily combine under these circumstances, forming an alloy that is liquid whilst hot, but becomes hard and brittle when cold. The contents of the tube, while still hot and liquid, are quickly poured out on a clean plate, and, when cool, broken up in small lumps, which are then immediately placed in a well corked or stoppered bottle.

The way I employ this amalgam is simply to place the suspected solution, or solid matter along with a little water, in the bottom of a test glass, then add a small bit of the amalgam, about the size of a grain of wheat, and lastly, place without delay, on the top of the glass, a piece of white filtering paper or the cover of a white porcelain crucible moistened with a drop of a dilute solution of nitrate of silver, slightly acidulated with nitric acid, when if arsenic is present, a dull black or deep brown stain on the paper, or a dark silvery one on the porcelain, will be quickly developed in the part moistened, owing to the silver of the salt being reduced to the metallic condition by the agency of the arseniuretted hydrogen thus evolved, which, coming in contact with the nitrate of silver, gives rise to the following reaction: $H_3As + 6\ AgNO_3 + 3H_2O = 6\ HNO_3 + H_3AsO_3 + 3\ Ag_2$.

The silver solution, which I have found to answer very well for this purpose, was made by dissolving twenty grains of the nitrate in an ounce of distilled water, and then adding two drops of strong nitric acid, to render the solution slightly acid. I may further add that I generally place a small disc of bibulous paper between the mixture in the glass and the paper or cover moistened with the silver solution, to intercept any particles of the liquid which might otherwise be projected against them, producing there minute black spots, and thus interfering with the results of this test.

I have found that exceedingly minute quantities of arsenic can be readily detected by this very simple process; thus the one thousandth part of a grain of arsenious acid, dissolved in one cubic centimetre of distilled water, gives a very decided effect in a few moments; but much smaller quantities are detectable by it; thus the one hundred thousandth or even the one millionth part of a grain of arsenious acid, dissolved in the same quantity of water (one cubic centimetre), will afford, by the blackening of the silver salt, after a little time, an indication of the presence of arsenic. I have also ascertained that this method of detecting arsenic is not alone directly applicable to where it exists as arsenious acid, but likewise to several other compounds of arsenic, whether they are soluble or insoluble in water—thus, for example, the two sulphides of arsenic (orpiment and realgar), the alkaline arseniates, and even metallic arsenic itself if reduced to powder, will readily show their arsenical nature by this test; and we may in a few moments detect by it the occurrence of arsenic in different green, yellow, and orange pigments, which are still much employed in the manufacture of wall papers, in painting, and in the colouring of certain textile, and other articles used in dress or for ornamentation. Thus, for example, if a little of the colouring matter of any arsenical pigment be scraped off from a wall paper, or a small piece of the paper itself be taken and placed in a test-glass with a little water, and having being stirred or shaken to detach the colour, a piece of the amalgam be added, it will, by the blackening of the silver salt employed as before described, soon indicate the presence of arsenic. In the same way it can be easily demonstrated that the colouring matter in certain green tarletans, calicoes, and other articles used for dress or for ornament, are arsenical. I may further state that the presence of organic matter seems to interfere but little with this test, for I have found that very minute quantities of arsenious acid, when mixed with considerable amounts of milk, tea, coffee, ale, porter, soup, or stirabout, could, with almost the same facility, be detected by this method, as where they were only simply dissolved in water; thus showing that the cases to which it is applicable are very extended.

But I should here observe that, as in the case of Marsh's original method, there is one other metal which, under certain circumstances, will produce with the sodium amalgam results closely resembling those occasioned by arsenic; the metal I refer to is antimony, which is capable of uniting with nascent hydrogen to form a gas (antimoniuretted hydrogen), which, coming in contact with nitrate of silver, produces a black antimonide of that metal, by the following reaction: $H_3\,Sb + 3\,Ag\,NO_3 = Ag_3\,Sb + 3\,HNO_3$, and the blackening of the silver salt from the formation of that compound might be easily mistaken for the effect produced by the arsenical gas.

But owing to the fact, first pointed out by Fleitmann, that antimoniuretted hydrogen is not evolved (except, perhaps, as a mere trace), from strongly alkaline solutions, though the conditions may exist there for its formation, and as the action of the sodium amalgam is to render the mixture quickly alkaline, there will be only a very minute quantity of the antimony that may be present so evolved; and, by previously rendering the mixture strongly alkaline, we may almost altogether prevent the evolution of that gas. If, however, we make the mixture containing the antimony in solution first strongly acid, and then add the amalgam, or even acidify after its addition, the antimoniuretted hydrogen will be evolved in abundance, producing a deep black stain on the paper moistened with the nitrate of silver; and, for the purpose of this acidification, I have found that tartaric acid answers very well. As the presence of alkalies in solution do not interfere with the evolution of the arsenical gas, this is itself a means of distinguishing the two metals, arsenic and antimony.

But it may be occasionally necessary to determine whether the effects observed on the paper moistened with nitrate of silver are due to arsenic or to antimony. There are different methods by which we may determine this question; but the one I have found the simplest and on the whole, the most satisfactory, is to digest the paper stain in sulphide of ammonium, when the arsenic or antimony present will be converted into a sulphide, and dissolved by the excess of the alkaline salt, leaving the silver sulphide undissolved, and adhering principally to the paper—the alkaline solution, on being evaporated to dryness, will, in the case of arsenic, leave a bright yellow residue almost insoluble in hydrochloric acid, whereas in the case of antimony, an orange one will remain, which readily dissolves in that acid, at least on the application of heat.

Before concluding, I wish to observe, that according to some experiments recently made by Dr. Russell, it appears that hydrogen alone is capable of reducing solutions of nitrate of silver to the metallic state; but this action, even from his observations, is an exceedingly slow one, and takes place to a very minute extent in dilute solutions. On the other hand, M. H. Pellet maintains, that hydrogen carefully freed from acid and arsenic, by passing it through solutions of soda and of nitrate of silver, has no action on that salt at the ordinary temperature. But he states, that nitrate of silver which has been fused possesses an alkaline reaction in solution, and that a slight precipitate is produced in such by pure hydrogen; if, however, he observes, a drop or two of nitric acid be added, then nothing is precipitated. Be this as it may, as regards the reducing action of pure hydrogen, I found in an experiment I made, that hydrogen which had been passed through solutions of caustic soda, and of nitrate of silver, and was afterwards brought in contact with a porcelain crucible cover, moistened with the dilute and acidulated solution of nitrate of silver already noticed, produced only the faintest possible effect, even after several hours' exposure to a stream of this gas, and this very slight action might possibly be due to the hydrogen not being perfectly freed from its impurities. Consequently, it is very doubtful that any reduction of the silver salt from the hydrogen alone will occur under the circumstances of the proposed test. Finally, I must observe, that where paper moistened with the silver solution is used to detect arsenic or antimony, we must bear in mind that nitrate of silver will alone, after some time, blacken the paper, especially if it is exposed to the light; but this gradual change which is so produced is very unlike the rapid effect that takes place where either arseniuretted or antimoniuretted hydrogen acts on paper moistened with that silver salt.

XXXVI.—Further Researches on the Dissociation of Molecules in Solution. By Charles R. C. Tichborne, Ph. D., F. C. S., &c.

[Read June 14, 1875.]

In my previous researches in connexion with the dissociation of the molecules, which are generally known as salts, I have shown that there is probably in every case a partial separation of the base, determined by the thermal force acting upon these molecules when in solution.* The first basic salt produced does not differ much from the original molecule, but its basicity goes on increasing with the increment of heat, obtained, we will say, by increased pressure, until a complete temporary analysis of the salt is effected, even if the result of the action is not a permanent decomposition. We may also view these extreme cases as partaking of the nature of gaseous dissociation, it having been proved by Dr. Andrews that there is no hard line of demarcation between the liquid and gaseous state of matter.

I have also determined that the first thermanalytic action of heat upon hydrated salts, although still in the presence of water, is to gradually and completely dehydrate the salts, and to render them anhydrous. The water of hydration, so called, being merely the last and crowning portion of the compound molecule, and therefore the portion of the molecule least amenable to the chemical or molecular force,† it is not necessary to dwell upon this point of the subject any further than to bear in mind that we are actually operating upon the anhydrous salt. Presuming, then, that the thermanalytic force being antagonistic to the chemical force, and that, step by step, the compound is analyzed to its elementary molecules, it follows that as the basylous molecules are separated, so the stylous or acid molecules must be also liberated or separated. The following experiments, whilst establishing this fact, are merely taken as examples from many others in consideration of their simplicity.

It becomes evident that, in working under pressure, there cannot be any indications of molecular change better than colour tests, similar to those which serve us so well in ordinary qualitative analysis, and, therefore, it is better to confine ourselves, as much as possible, to such reactions.

There are many instances which may be cited as setting forth with the dissociation of the stylous group, but which would not come under my designation of dissociation, because they are attended with permanent decomposition. As an example of dissociation, let us take the well-known salts formed by the combination of chromic acid and

* Report on the Molecular Dissociation by Heat of Compounds in Solution. Proceedings Royal Irish Academy, Vol. I., Ser. II., Science, p. 169.

† On the Action of Heat upon Solutions of Hydrated Salts. Proceedings Royal Irish Academy, Vol. I., Ser. II., Science, p. 247.

potassium. Solutions of the yellow or neutral chromate of potassium, and also the red, or acid, chromate of potassium, were made of such a strength that 10,000 parts contained an equivalent of each salt. In other words, the yellow solution of chromate of potassium contained 194·5 parts of salt in the 10,000 parts, and the red chromate contained 147·5 parts in the 10,000, but each solution contained the same amount of the colour-producing molecule, or the chromic acid, only in different conditions of saturation. If we take 1000 parts of the yellow solution of chromate of potassium, we find that, even at the ordinary temperature, 15·5 C., partial dissociation has occurred. Presuming that we have started with perfectly neutral crystals, we shall find that, on the addition of a volumetric solution of soda, the colour becomes lighter until a quantity has been added which represents ·059 of red chromic salt; therefore we are justified in coming to the conclusion that at a temperature of 15·5, sufficient of the acid is dissociated from the neutral salt to form that quantity of the acid salt—that in fact there is even a slight or partial dissociation in the act of solution. If this neutral solution is then brought to the boiling point, and we use some considerable bulk for the experiment, we shall find that a marked decomposition has taken place in the salt, as evidenced in the change of colour. In a few carefully conducted experiments it was found that it gave a decomposition which averaged about $\frac{1}{26}$th of the yellow salt present; *e.g.*, 1000 parts of the solution of the yellow salt, mentioned above, were brought rapidly to the boil in a flask furnished with a long neck, so as to condense the steam which flowed back into the flask. Another 1000 parts of the yellow solution was then placed into another flask, and at a temperature of 15·5 C. A standard solution of sulphuric acid was added, degree by degree, until the exact colour was obtained, which agreed with the boiling solution of chromate. The standard solution contained one-half an equivalent in 10,000 parts of sulphuric acid, and fifty-one degrees had been used, which corresponded with 0·75 parts of the red salt formed, and which also represented ·51 parts of chromic anhydride dissociated at a temperature of 100° C. from 19·45 parts of the salt.

If the neutral solution of yellow chromate be now inclosed in a sealed tube (such a one as described in my previous paper*), and submitted to a high temperature, say 250° C., it would appear that about 75 per cent. of the yellow chromate will be converted into the red salt.† The experiments in connexion with chromates may throw some considerable light upon one of those mysteries of the photographic art which up to the present time has not been properly or satisfactorily explained. One, if not the most important, method of taking sun-pictures is based upon the action of light upon a film of gelatine, containing a little red chromate of potassium. Such a mixture is highly

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* l. c., p. 250.

† Chromic acid is said to form four salts with potassium: K_2OCrO_3, K_2O2CrO_3 K_2O3CrO_3, and K_2O4CrO_3.

sensitive to light, the gelatine becoming insoluble under the faintly oxidizing tendency of the chromic salt. This film is also found, however, to be sensitive to other agencies, and it has been this phenomenon that has puzzled photographers. Such a film becomes insoluble by moisture, heat, and lapse of time. It would appear in fact that light is not absolutely necessary to bring about the change. The experiments detailed will go far to explain all these phases of the phenomenon. We find that moisture means solution, or the mobility of the chemical molecules, which is absolutely necessary to chemical change, and that solution, even at ordinary temperatures, means a partial decomposition, however infinitesimal that decomposition may be. But when we add time to this, there is no limit to put upon the results of this decomposition. We also see how greatly the partial decomposition of the chromic salt is accelerated by each increment of heat, and therefore we can understand how such a film would be sensitive to temperature.

The salts used in these experiments were not those ordinarily found in commerce, because their neutrality is not sufficiently well marked for the determination of the delicate reactions detailed above. The yellow chromate was found particularly unreliable in this respect. It was purified by adding a few drops of caustic potash, and re-crystallizing twice. The bichromate was purified by adding a few drops of dilute sulphuric acid, crystallizing to a slight extent, and rejecting these first crystals, and then taking off a second and more extensive crop of crystals. These last crystals, on re-crystallization, yielded a salt sufficiently pure for the experiments. Solutions made with the two salts exhibited a marked difference in shade from the commercial crystals.

Another illustration of the dissociation of the acid molecule is well shown in the uranic nitrate: uranic nitrate is, if evaporated to dryness and submitted to heat, decomposed into pure uranic hydrate and a basic nitrate. It would probably therefore be a salt which would easily dissociate in solution, even at a moderate temperature, but at the same time, it affords a colour test of the dissociation of the acid molecule, because the presence of free nitric acid causes in the bright yellow solution of uranic nitrate an orange coloration.

It is stated that a solution of uranic nitrate is decomposed at a moderate heat with the deposition of a precipitate, the composition of which has not been determined. I have not found this to be the case, however, in sealed tubes; for it seems to bear with impunity a temperature which must be close upon 130° C. Therefore we are led to infer that such a decomposition results from the loss of nitric acid. When such a solution is heated under these conditions, it gradually becomes more and more orange. Many other instances may be given of the dissociation of the acid molecule, and we need hardly go further than the decompositions resulting from the dissociation, when either the acid or the base is volatile. In the case of carbonic anhydride this dissociation results in the production of basic carbonates, such as

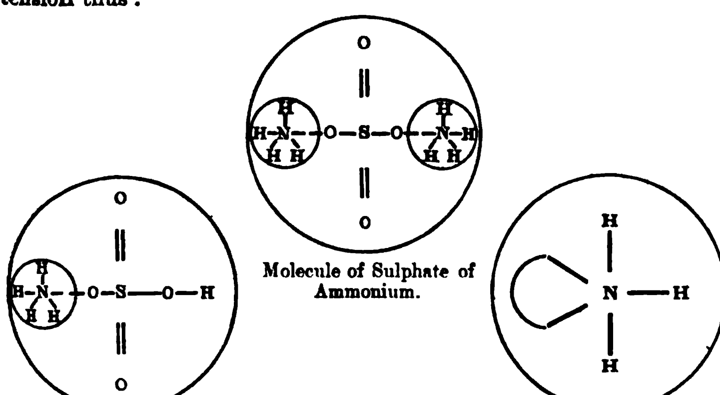
Carbonate of Magnesium ($(MgCO_3)_3MgO5H_2O$).
Carbonate of Zinc ($ZnCO_3\ (ZnO)_2\ 3H_2O$).
Carbonate of Lead ($6PbCO_3PbOH_2O$.)

In the case of a volatile base and acid such as carbonate of ammonium, we have a partial dissociation, attended with both loss of acid and base, but which from the tendency to assimilate the acid molecule M′ H A″ is productive of a curious decomposition. The two following experiments will illustrate this in a striking manner.

They are performed with the most permanent of the ammonium salts, the sulphate $(NH_4)_2SO_4$, and the most unstable, viz. $(NH_4)_2CO_3$, the normal carbonate. We find that at a very slight increase of temperature the sulphate molecule is no longer permanent. Crystals of sulphate of ammonium were taken which were perfectly pure and neutral. A poreclain crucible was filled with these crystals, and a sufficient quantity of water was added to moisten them. The crucible was placed in a water bath provided with a thermometer, and covered with a beaker, a piece of blue litmus was placed upon the surface of the moistened sulphate, and a piece of red litmus in the beaker. At a temperature 16° C. a slight decomposition took place, but at 20° C. the tension of the gaseous base was so raised that rapid decomposition set in, the litmus paper in the salt becoming red from the formation of NH_4 HSO_4 and the litmus paper in the beaker, which was originally red, becoming blue from evolved ammonia.

Water is essential to such a phenomenon, and no decomposition can be perceived with the dry salt, under such a condition, mobility of the atoms being essential.

Carbonate of ammonium NH_4 CO_3 was formed, by treating ordinary carbonate with ammonia, and the result was a moist salt, but still in the form of a powder. It was placed in a vessel the sides of which were perfectly cleaned: this vessel was then surrounded with a freezing mixture of a considerable power, and at a temperature of about 4° C. it became nearly odourless, and at a much lower temperature perfectly so. Thus we find that the most permanent salt of ammonia is in a state of tension thus:



Molecule of Sulphate of Ammonium dissociated by heat into two molecules.

or it may be represented by the equation

$$(NH_4)_2SO_4 = NH_4H\ SO_4 + NH_3.$$

and the second experiment by the equation

$$(NH_4)_2\ CO_3 = NH_4\ H\ CO_3 + NH_3.$$

If we substituted a less volatile base in such a reaction we ought only to have the phenomenon which is generally understood under the designation of dissociation. The result, however, in this case is a permanent decomposition.

Nitrates when heated under pressure with oxidizable metals are rapidily decomposed, and the surface of the metal corroded. Many of the boiler accidents have been probably so caused; for we may extend these remarks to the other salts found in water, although none seem so energetic upon the surface of the metal as the nitrates, owing to the ease with which that acid yields its oxygen.

We cannot conclude this part of our subject without pointing out how strongly these researches upon the dissociation of the acidulous and basylous molecules bear upon the technical processes upon which the arts and manufactures rest. Le Blanc's ingenious but roundabout process for the production of soda and hydrochloric acid, seems threatened by dissociation, and already the process for the production of chlorine directly from hydrochloric acid and air* is based upon similar reactions to those described in this report.

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* "On a New Chlorine Process without Manganese." By Henry Deacon, F. C. S., British Association. Report, 1870, Transactions of the Sections, p. 54.

XXXVII.—REPORT ON THE IRISH DIATOMACEÆ. By the REV. EUGENE O'MEARA, M. A. Part I. (With Plates 26 to 35.)

[Read June 28, 1875.]

IT is now just a century, since in 1773, O. F. Müller discovered the first known diatomaceous form; nor was it till ten years after, the same distinguished author was able to add two new forms to the list. In the year 1824 Agardh published his "Systema Algarum;" and then the number of species was forty-nine, comprehended under eight genera. But if in this province of Natural Science the progress was slow during the first half century, it has been very rapid in the last, owing not only to the number of eminent labourers in this field of research, but also to the greatly improved means of investigation. The number of species in Europe alone, as computed by Rabenhorst in his index, is about 4000. This may be beyond the mark, but certainly Pfitzer is far short of it when he fixes the total number of known species at about 1000. It is not necessary to enumerate the many authors to whose useful labours the students of this branch of Science are indebted, but special notice should be made of Kützing, who explored the whole surface of the globe; and of Ehrenberg, who, not content with the same ample field of investigation, extended his researches into the bowels of the earth. But no authors, perhaps, have contributed so much to the extent and accuracy of our knowledge, as those who have restricted their labours to some special families, or to the collection and examination of the forms incidental to some country or district. The treatise on the Diatomaceæ of the Clyde has earned for Gregory an imperishable name. The Austrian forms have been described by Grunow. The Prussian by Schuman. The Danish by Heiberg. Those of Sweden and Norway by Cleve, and those of Great Britain by Smith in his admirable Synopsis.

No country would appear more favourable to the growth of these forms than our own, with its extensive sea-coast indented with numerous bays, its rivers and lakes, and mountain ranges. And yet it is strange that Smith, an Irishman, at least labouring professionally in Ireland, should have done but little in exploring its resources, as appears from the fact that, in the case of 389 forms figured and described by him as British, there are not more than about one hundred for which Irish localities have been assigned. Hence it might be supposed that the climate of Ireland is not favourable to the growth of Diatomaceous forms—an impression which is not justified by the fact, as I hope to prove by the present work.

For many years the intervals of professional engagements had been devoted by me to the collection and study of the Irish Diatomaceæ; and a large amount of material had been gathered and arranged when

I was favoured with the request of the Royal Irish Academy to prepare a list of the forms to be met with in this country—a request with which I unhesitatingly complied. Had I been content with furnishing an inventory of the forms I had found, the task I had undertaken might have been speedily performed; but my anxiety was to render the work as complete and as useful to my fellow-students as I could, and as worthy of the reputation of the Royal Irish Academy as it was possible for me to make it. With this view I determined to explore new localities, and to search more carefully, districts I had previously examined. I was anxious also to avail myself of the labours of the most distinguished authors on the subject, and was therefore obliged to acquire a knowledge of languages with which I was previously unacquainted.

For all this, time was required, and I refer to the subject for the purpose of showing that the long period that has elapsed since the task was undertaken has been busily, and I hope not fruitlessly, occupied. No authentically named specimens were available; and this proved to me a source of much additional labour and delay. Those who are practically acquainted with the Diatomaceæ are aware how difficult it is sometimes under the most favourable circumstances to identify a form. The difficulty is enhanced in cases in which the original form, observed under the disadvantage of inferior instruments, has been inadequately described; and when a mistake has been made in the figure or the description, the only satisfactory means of identification is the inspection of the specimen. Hence some idea may be formed of the difficulty and delay arising from the circumstance of there being no authentic specimens preserved in any of the Collections or Herbaria of Dublin. Many are the friends who have kindly assisted me in the prosecution of this work, but special acknowledgments on my part are due to Professor E. Perceval Wright, M.D., not only for the loan of collections but also of books and objectives, to Rev. Maxwell H. Close, and A. G. More, Esq., whose collections have added numerous forms to my list, as well as new localities for many others; and also to Dr. David Moore, whose many and valuable collections were kindly placed at my disposal.

The name of Bacillariaceæ was employed to designate this group of organisms at a time when little of their structure and habits, except their outward form, was known; and Pfitzer maintains that this designation should be retained because of its priority: but I have adopted the more modern name of Diatomaceæ, not only because it is more pronounceable, but specially because it is more characteristic and more generally known.

The question, what is the proper position of the Diatomaceæ in the classification of organized beings, has been variously answered. The first known species were by their discoverers included amongst the Confervaceæ; the extraordinary movements, however, of Bacillaria paxillifer, noticed by Müller, induced that author to identify it with the genus Vibrio; and the position assigned to this form, as well as the rapid motion by which it is characterised, may have insensibly inclined succeeding observers to assign to the Diatomaceæ generally a place in the Animal Kingdom. This theory is supported by the authority of the illustrious Ehrenberg, who regarded the numerous globules noticeable in the cells as so many stomachs, and therefore gave to a group embracing these and other forms the general designation of Polygastricæ. But notwithstanding the deference justly due to so great an authority, more recent observers are, I may say, unanimously of opinion that the Diatomaceæ belong to the Vegetable Kingdom—an opinion sustained by the analogy which the forms of this group exhibit as regards their general structure, and more especially by the mode of reproduction which they possess in common with other organisms generally regarded as vegetable.

The Motion of the Diatomaceæ.

One of the first phenomena which attracts the notice of the students of the Diatomaceæ is the extraordinary power of motion with which the frustules are endowed. To account for this motion, various theories have been suggested, reducible to two general classes. By some it has been supposed that in the process of imbibing water containing nourishment and expelling what is superfluous, currents are produced which have the effect of propelling the frustules backwards and forwards through the water. As concerns this hypothesis, I quite concur with the opinion expressed by Ralfs, that it should be regarded rather as a figment of the imagination than founded on the observation of facts. Others have suggested that the frustules are furnished with special organs of locomotion. The occurrence of hair-like processes on the frustules has afforded a colourable reason for such a statement; they are, however, only occasional, and have the appearance of parasitic growth, rather than of normal organs of the plant. Ehrenberg conceived that a pedal organ was extruded from what he regarded as an orifice in the centre of the valve: but so far from the existence of such an organ having been satisfactorily sustained, the fact that what that eminent observer, as well as others of deservedly high reputation, considered to be an opening, is now generally regarded as a thickening of the silicious plate, is fatal to the theory. So while the motion of the Diatomaceæ continues to excite attention, it must be confessed that the mechanical agency by which the motion is effected remains unexplained.

Structure of the Cell.

There is one remarkable feature in the structure of the Diatomaceæ which distinguishes them from cognate organisms, that is, the fact that the cell is invested with a silicious covering, consisting of two distinct plates, more or less parallel to one another, and held together by a rim or hoop. This silicious covering has been appropriately assimilated to a pill-box, consisting of the box itself and the cover which slips over it; and if we suppose the cover to be of the same depth as the box, or nearly so, we have a structure on a large scale which nearly resembles the silicious covering of such Diatomaceous species as possess a circular form, and which with some modification may be taken to illustrate the general plan on which the silicious part of the cell of Diatoms is constructed. In the larger forms it may easily be noticed that one valve of the frustule, with its accompanying rim or hoop, is smaller than the other into which it fits, as the slides of a telescope fit into one another. It has been supposed that in the parent frustule the two valves are of the same size, and that the diminution in the dimensions of one valve is owing to the fact of its being developed within the rim of the primary valve, and is consequently smaller than it by the thickness of the rim. Pfitzer, however, has remarked that in some cases at least the difference in size is noticeable in the mother cell, in which one valve is secreted in the first instance, and then the opposite valve is formed within the former. This remark is worthy of notice and should be borne in mind when cases of conjugation come under view, in order to ascertain whether the occurrence is casual, or whether the same process takes place in the other species of Diatomaceæ. To the distinguished author just named belongs the merit of having contributed more than any other to the extent and accuracy of our knowledge concerning the various parts and disposition of the cell-contents. There is first the plasm-sac, consisting of a fine colourless plasm, forming a closed sac of the shape of the cell, and in which the cell-contents are enveloped. It is often very difficult for the observer to make himself certain of the existence of this sac, because its refractive power differs but slightly from that of water, but the structure becomes apparent immediately on the application of dilute hydrochloric acid. The effect of this re-agent is to produce an instantaneous contraction of the sac, which at first, as it recedes from the cell-wall, preserves the form of the cell and still maintains connexion with it by means of a few pellucid threads, but after some time it becomes contracted into a round mass. This result is accomplished most effectively by the use of osmic acid at the strength one per cent. Iodine gives a bright yellow colour to the plasm-sac. Within the plasm-sac, and in close proximity to it, is the structure to which Pfitzer has given the name of Endochrome-plates, varying in number and position in the various genera. Some possess two of these plates, others only one. In the Naviculæ these plates, two in number, lie one at either side, the middle of the plate corresponding with the middle of the hoop or connecting band, whence they pass on either side towards the median line, leaving a small narrow space down the middle of the valve free; in other genera there is but one such plate, variously disposed. They consist of a thick substance, and are of the same colour thoroughout, varying from light yellow to dark yellowish brown. The plasm of which these plates consist differs in density from the plasm which forms the plasm-sac and the structure which is called the middle-mass. In case the normal condition of the cell-contents be disturbed by fracture of the silicious epiderm, the endochrome plates go together, and never commingle with the material of the plasm-sac. If the colouring matter be discharged by alcohol, the demarcation of the endochrome plate from the rest of the plasm can be readily distinguished. Within the folds of the endochrome plates is found in some a collection of plasm, which Pfitzer calls the "middle plasm-mass," described by Ehrenberg as resembling "the embyro in an egg;" in the Naviculæ it forms generally an irregular quadrangle. Vacuoles and oil globules occur imbedded in this middle plasm-mass, and appear distinctly in consequence of their strong refractive power. In the middle of this plasm-mass a central vesicle is observable in some genera, but is not equally distinct in all species. And although in some cases it cannot be discovered, even with the most skilful management, Pfitzer considers that nevertheless the statement of Lüders may be correct, that no Diatomaceous cell is destitute of such a vesicle, because although in many cases no such structure can be detected by ordinary means, it becomes apparent by the application of re-agents, the most effective for the purpose being dilute hydrochloric acid.

Besides the parts already specified, there have been observed in some of the Diatomaceæ a water-like fluid substance, and oil-globules, varying in size. These latter occur swimming freely in the cell, but in greater number upon the inner surface of the plasm-sac. In consequence of their strong refractive power they strike the eye at once, and are changed into a black colour by the use of osmic acid. As they readily combine, they have no investing pellicle. It is thought that in proportion as the oil-globules abound, the cells have suffered from the want of pure water, and that the appearance of the larger oil-globules is a sign that the cell has attained its full maturity, and that its resources have been exhausted. The oil-globules afford a means of answering the question whether the cell contents are of a watery or of a gelatinous consistency. In favour of the former view, Pfitzer refers to the fact that very weak acid produces an immediate shrinking of the plasm-sac, and also to his observation that the oil-globules can be moved about with facility, which could not occur if the surrounding matter were of a gelatinous thickness. And this opinion of Pfitzer has been corroborated by Föcke, who discovered that the oil-globules, in consequence of their light specific gravity, accumulate on the upper surface of the cell, and change their position in case the frustule is turned upside down.

The Reproduction of the Diatomaceæ

Is a subject of deep interest, requiring some explanatory remarks. The ordinary mode of increase is by self-division, as it has been termed. The cell-contents within the enclosure of the silicious epiderm separate into two distinct masses. As these develop they push the valves of tho mother-cell more and more widely asunder. A new silicious valve is secreted by each of tho two masses, on the side opposite to the original valves. And, when this process has been completed, two distinct frustules are formed, the silicious valves in each being one of the valves of the parent-cell, and a newly secreted valve apposed to it. During the active life of the cell this process of self-division is continued, and is rapidly completed. On this subject Smith observes, "I have been unable to ascertain the time occupied in a single act of self-division; but, supposing it to be completed in twenty-four hours, we should have as the progeny of a single frustule the amazing number of one thousand millions in a single month—a circumstance which will, in some degree, explain the sudden, or, at least, rapid appearance of these organisms in localities where they were, but a short time previously, either unrecognised or sparingly diffused."—British Diatomaceæ, vol. i., p. 25.

It seems probable that the Diatomaceæ are sometimes reproduced by zoospores. Rabenhorst records his having observed a specimen of Melosira varians, in which, from the sporangial frustule, there issued what appeared to be germs, and has described the process. Die Susswasser Diatomaceen, T. x., fig. 18 c. A similar occurrence was noticed by myself in 1858, in the case of Pleurosigma Spencerii: and Castracane has recorded two or three observations of the same kind. So far as I am aware, the development of these zoospores, if such they be, has in no case been traced through its successive stages to its ultimate result; but there is nothing unreasonable in the presumption that the phenomenon may be a phase of the reproductive process.

Another mode of reproduction in the Diatomaceæ is by conjugation, of which, according to Smith, there are four distinct phases. First. The union of two parent frustules issues in the formation of two sporangia. Second. Two parent frustules produce only one sporangium. Third. A single frustule develops a single sporangium. Fourth. A single parent frustule produces two sporangia. In the first stage of the conjugative process, a mucous sac is secreted by the parent frustules, within which the sporangia are developed; these sporangia, in some cases, lie parallel, and in other species at an angle with the parent frustules or valves, as the case may be. A phase of conjugation, quite distinct from the four just referred to, came under my notice, many years ago, in the case of Diatoma vulgare.* I observed numerous instances of the long chain of concatenated frustules in their normal condition with a sudden jerk fold themselves into a solid mass. In a very brief period a mucous sac was seen to develop itself, inclosing the whole mass of frustules, and in some cases enveloping forms of a different species which happened to be in immediate proximity. By degrees the mucous sac pushed itself forward, sometimes in a single projection, sometimes in two, and into these prolongations the cell-contents of tho

* Natural History Review, 1859, vol. vi., page 90, Pl. ix.

frustules were poured; the prolongations became gradually more and more constricted at the base, until ultimately they were completely cut off from the mucous sac, in which the frustules remained folded, in a state of perfect inanition. The process described was completed within the space of a few hours, so that in innumerable instances I was able to trace it from beginning to end—that is, from the commencement of conjugation up to the formation of the sporangia. Smith refers to cases of Cocconema cistula, and also of Synedra radians, having been found aggregated in great numbers and enclosed in mucous sacs similar to what has been described in the case of Diatoma vulgare; and all three cases seem to me to represent the same phase of conjugation: and I am disposed to think that, as in Diatoma vulgare, so in the other two cases, the encysted frustules were not, as Smith considered them, young frustules in course of development from a sporangium, but parent frustules preparing to produce sporangia.

Instances of conjugation in any of its varied forms are rarely to be met with. When Smith published his Synopsis, in 1856, cases had been observed in thirty species, included in seventeen distinct genera; and during the interval of fifteen years that had elapsed when Pfitzer published his work, "Uber Bau und Entwicklung der Bacillariaceen," only twenty-eight cases had been added to the list, exclusive of that of Diatoma vulgare, making a total of sixty-one. This remarkable fact Smith thus endeavours to account for: "During conjugation the process of self-division is arrested, the general mucous envelope or stratum produced during self-division is dissolved, and the conjugating pairs of frustules become detached from the original mass; they are thus more readily borne away and dispersed in the surrounding currents, or by the movements of worms or insects, and their detection becomes in consequence more casual and difficult." It is not improbable, however, that the mode of collecting, and the time that is often suffered to elapse before the collection is submitted to investigation, may have more to do with the fact. And, in confirmation of this view, I would mention that, although I have for very many years been engaged in the study of the Diatomaceæ, and have made innumerable collections at all seasons of the year, I have not been so fortunate in observing instances of conjugation as some friends whose collections have been made with a view to the discovery of other organisms. Their gatherings are usually made in large bottles containing a considerable quantity of water, by which the specimens may be preserved for a long time in their normal state—my gatherings being put up in minute bottles with little water, so that the vigour of the frustules is greatly abated before an opportunity of examining them may be afforded. As to the seasons of the year in which conjugation is most likely to occur, the facts hitherto accumulated do not afford much information. Besides the case of Diatome vulgare which I observed in conjugation in the month of August, seventy-two observations, with specification of date, have been recorded, making seventy-three in all. Of these, twenty-three occurred in spring, twenty in summer, twenty-four in autumn, and only six in winter. The paucity of such observations during the winter may, however, be traceable to the fact that then, in consequence of the inclemency of the weather, fewer gatherings are made, than because the process of conjugation is of less frequent occurrence during the season.

Classification.

In the various systems of classification, the several authors have treated the facts they had to arrange as Procrustes is said to have dealt with his guests: "Qui ad lectum hospites emensus breviores extendebat longiores decurtabat." How just this observation is will be obvious if we consider Pfitzer's fair criticisms on the anomalies of the systems of classification hitherto propounded. All systems are artificial; and when we consider the immensity and variety of Nature's productions, we cannot wonder if in every group some organisms will be found to exist which cannot, without violence, be reduced into the order proposed. Every plan of arrangement will be liable to objection; and that may be regarded as the best which is the most obvious, the most simple, the most comprehensive, and productive of the fewest anomalies.

Pfitzer considers that the imperfections of the existing systems are traceable to the fact that the ground-plan has been laid down on a single line, and as a remedy suggests a system of classification based on several concurrent lines, the principal of which are the character and number of the endochrome-plates, the structure of the sporangia, and the symmetrical or unsymmetrical form of the frustules in their several aspects. Upon these lines Pfitzer has skilfully constructed a most ingenious system of arrangement; but however great its merits as a philosophical abstraction, it appears to me liable to objection on practical grounds. The dislocation of analogous species chargeable on former systems, so far from being avoided, is scarcely, if at all, diminished by the proposed plan. Here we have the Nitzschieæ brought into close contact with the Naviculeæ; the symmetrical Synedriæ and the unsymmetrical Eunotieæ are placed side by side, and in near proximity to the Surirelleæ. The symmetrical Fragilarieæ are severed from the symmetrical Synedriæ, and associated with the unsymmetrical Meridieæ. The Tabellarieæ are separated from the Fragilarieæ and ranged with the Lichmophoreæ. The character of the endochrome-plates seems to me a condition of too recondite a nature to admit of practical application; besides, the induction of facts on the subject is, as yet, far too limited to justify its adoption. As to the reproductive process and its results, if our knowledge on the subject were sufficiently comprehensive, it would furnish most valuable help towards the construction of a satisfactory arrangement of the Diatomaceæ; but, unhappily, in the great dearth of authentic facts illustrative of the subject, we are not warranted in using the knowledge we have as a ground plan of a general systematic arrangement.

The reproductive process has not been observed in more than about sixty-five species, and in some of these cases there is a difference of opinion as to the facts. A system, therefore, in which this process constitutes an important part of the ground plan, is practically objectionable, as founded on hypothesis.

The system which appears to me to have most to recommend it is that which has been matured by Heiberg, founded on the symmetrical or unsymmetrical structure of the frustules in their various aspects. There are two principal aspects in which a diatomaceous frustule may be regarded—the front view, in which the hoop or connecting band is presented to the eye, and the side view, in which one or other of the two valves is under observation; and in both these positions the longitudinal and transverse axes are to be considered. If in these two positions, and in these varied views, exact symmetry obtains, the frustule is said to be symmetrical in all its aspects; but if the two opposite valves are not uniform, or the portions of the valves on either side of the transverse or longitudinal axis, on side view or front view, do not exhibit the same proportions or outline, the frustule is said to be unsymmetrical on that view or axis on which the difference of form is observable. Such is the ground plan of Heiberg's systematic arrangement, and which I have adopted in the present report. It is not, indeed, wholly free from the objections to which other systems are liable, and, possibly, may be open to others peculiarly its own; but still the principle on which the arrangement is based commends itself as being at once most simple, most comprehensive, and most easily applied.

There are, however, two very important yet subordinate features of Heiberg's system, in regard to which I cannot adopt the views of that distinguished author. He ranges the numerous Cuneate species as aberrant varieties of the families which in other respects they most closely resemble; for example, Meridion and Asterionella are associated with the Fragilarieæ, under the distinctive appellation of Fragilarieæ cuneatæ; Podosphenia with the Striatilleæ, as Striatilleæ cuneatæ; Gomphonema and Cocconeis with the Naviculeæ, as Naviculeæ cuneatæ; whereas I have collected the numerous species with a cuneate outline, under the one general group of Cuneatæ. Again, the numerous species of Diatomaceæ, as is well known, exhibit various normal phases of growth. Some species are normally free, others attached by a short gelatinous cushion, or a larger or shorter stipes; the frustules in some genera are simple, while in others, after self-division, they remain in concatenate or ribbon-like filaments; in some genera the frustules are naked, while in others they are enveloped in mucous fronds, of which some are indefinite, others definite, forming simple or composite tubes. These peculiarities of growth Heiberg treats as of little significance; and accordingly, the genera Schizonema, Berkleya, and Colletonema, the frustules of which are included in tubes; Dickiea, the frustules of which are imbedded in a less definite mucous mass; Diadesmis, the frustules of which are united in short filaments; and Brebissonia Boeckei = Doryphora Boeckei, in which the frustules are stipitate, are notwithstanding these peculiarities of growth included as species under the genus Navicula. If Smith and others attached too much value to these subordinate features, and therefore separated the forms which exhibited them very far from the Naviculeæ, with which, as regards the general structure of the frustules, they are intimately related, Heiberg, on the other hand, I consider, has made a mistake in ignoring these peculiarities altogether. Recognising these various normal modes of growth as generic distinctions, I have included the forms as separate genera of the group Naviculeæ.

On the Distribution of the Diatomaceæ.

Some species are found only in fresh water, some only in salt water, while others select as their normal habitat places in which salt and fresh water habitually or occasionally commingle. I have indeed frequently found fresh water species in the stomachs of Ascidians dredged from a considerable depth in the sea; but their occurrence therein indicates the influx of fresh water in the immediate neighbourhood. And when marine forms are found in fresh water, as occasionally they may be, they indicate that the place is within the range of tidal influence.

An experienced observer will be able at a glance to ascertain whether a gathering is marine, or made in fresh or brackish water; and not only so, but will be able to discriminate the lacustrine and alpine forms from those incidental to other situations.

It is not possible to ascertain for what period the life of the Diatomaceæ continues, but when their course, be it long or short, is ended, the silicious covering sinks into the sediment: and when in the process of ages the sediment is solidified into rock, the exuviæ of the Diatoms that lived in the water during the period of deposition continue unaltered in their stony shroud. If the rock be decomposed by natural or artificial agencies, they may be extracted, and subjected to inspection; and if found in sufficient number, the species discovered may serve to illustrate the circumstances under which the deposit was formed.

Irrespective of the variety and symmetrical beauty of the Diatomaceæ, there is another circumstance which invests them with a peculiar interest: it is this, that no existing organism, whether it be vegetable or animal, can boast of so ancient a lineage. Countless have been the genera and species of living beings which flourished during the several geological periods, and of which no representatives survived the vicissitude which brought their epoch to a conclusion; but so far back in the annals of the earth as research has been able to trace the Diatomaceæ, the species which have been discovered are identical with those we have living at the present time. Numerous are the fossil or subfossil diatomaceous deposits which have been discovered in all parts of the globe; some the accumulations of marine, others of fresh water growth. Among these latter, the Irish deposits of Lough Mourne, Lough Islandreavy, Toombe Bridge, and Tollymore Park, are distinguished for the number and beauty of the species they contain: and we are indebted to the industry and intelligence of Mr. Gray, of Belfast, for the discovery of several sub-peat collections in various parts of the country. Nearly all the species contained in these various deposits have been found living at the present day; and it is a noteworthy fact, that the forms of these numerous species, however remote from one another in time and space, exhibit no appreciable divergency. As an illustration I may mention a few facts. Through the kindness of Mr. Kitton, of Norwich, I was supplied with a sample of a fresh water deposit from California, which contained numerous specimens of Synedra amphirhynchus, in no respect differing from the specimens of the same species I had found living a few days before, in a ditch not far from my residence in the county Dublin. Another deposit discovered by Dr. Moss, R. N., at Vancouver's Island, was sent to me for examination; and in it, among many other well-known forms, I found in great number, specimens of Navicula Americana, in all respects identical with forms of that species collected by my friend the Rev. George Davidson, from a deposit at Lough Canmore, in the north of Scotland, and those I had myself gathered some time ago in a living state on the borders of Lough Neagh. Count Castracane is of opinion that Diatoms must have existed even in the remote ages of the Palæozoic period. It remains to be proved whether this was so or not; but in his researches in the lignite formation of Urbino he has traced existing species so far back as the earlier epoch of the Tertiary formation. The specimen of lignite examined by this distinguished Italian naturalist was furnished by Professor Mici, who considered it to belong unquestionably to the Miocene period. This result is confirmed by the statement of Pfitzer, that all the fresh water, as well as marine forms hitherto discovered in the deposits of the Tertiary period, belong to existing genera and species. The generations of a Diatom in the space of a few months far exceed in number the generations of man from the earliest time to the present day; and yet we find that the individuals now living retain without alteration the characteristics which distinguished the species at the remotest time to which their existence can be traced. It might be alleged in this case that the silicious valves within which the valves of successive generations are developed necessarily impress the characters of the parent on the offspring; and that, therefore, any tendency to variation, however powerfully it might operate, would be checked by the irresistible force of external pressure. But the sporangia before the soft skin has become solidified by the secretion of silex are of a more plastic character, and afford a facility for variation if the cell-contents were endowed with any such tendency. And although the formation of sporangia has been observed in but very few instances, yet the frequent recurrence of this process of reproduction is forced on our acceptance as a necessary inference from the fact of the continuous existence of numerous species, despite of the law which regulates their multiplication by the process of self-division. As in each successive act of fission the newly-formed valves are smaller than those within which they have been secreted, the species would soon become extinct, were there not a provision made for its perpetuation in the process of sporangial reproduction. All the circumstances considered, I am led to regard the Diatomaceæ as a group of organism on which the Creator has impressed certain distinctive characteristics from which, through countless, successive ages, they have shown no tendency to depart.

LIST OF SPECIES.

A. *Frustules symmetrical.* 1. *Valves circular.*

FAMILY I. MELOSIREÆ, Kütz.

Frustules simple, or adhering in filaments. Circular on side view.

THIS family, since the adoption of it by Kützing, has undergone considerable modification in respect to the genera included within it. If we omit the ill-defined genus Pyxidicula, the forms he embraced within it, with the exception of Cyclotella, belonged to those genera distinguished by the filamentous character of their growth. Kützing recognised the analogy between these genera and those of which Coscinodiscus may be regarded as the type, but placed them widely apart, principally on the ground of the areolate striation of the latter. This character, however, is by no means universal, and even if it were, could scarcely justify so great a dislocation. Grunow, therefore, who is followed by Heiberg, includes among the Melosireæ all the symmetrical forms circular on the side view, irrespectively of their peculiarities of striation; thus establishing a very distinct and well-defined group which I adopt—my only difficulty in doing so arising from the fact that in the genus Cyclotella, some of the included species are waved on the front view, and for this reason can scarcely be considered as symmetrical in all aspects, in the sense of Grunow and Heiberg.

Genus I. MELOSIRA, Agardh.

Frustules filamentous. Convex at the ends, filaments free.

Melosira borrerii, (Greville.) Marine or brackish water.

Valves sub-hemispherical; girdlebands marked with conspicuous circles of cellules; filaments varying in breadth; colour of the desiccated filaments, a rich brown. (Pl. 26, fig. 1.)

Greville, in Hooker's Brit. Flora,* p. 401. Wm. Sm. B.D., Vol. ii., p. 56; Pl. L., fig. 330. Heiberg, De Danske Diat., p. 28.—M. moniliformis, Kütz. Bac., p. 53, T. iii., fig. 2. Raben. Fl. Eur., p. 38. Ralfs, in Pritch., p. 817, Pl. v., fig. 71.

River Slaney, near Killurin, Co. Wexford. Brackish ditch near Wexford town. Malahide, Dollymount strand, Howth, Co. Dublin. Sea weeds, Giants' Causeway, Co. Antrim. Brackish ditch near the town of Wicklow. R. Nannywater, Laytown, Co. Meath.

Melosira subflexilis, (Kütz.) Fresh or brackish water.

Frustules usually narrow elongate, slightly inflexed upon the margin. (Pl. 26, fig. 2.)

Kütz. Bac., p. 53, T. ii., fig. 13. Wm. Sm., B.D., Vol. ii., p. 57, Pl. LI., fig. 331. Heiberg, De Danske Diat., p. 28. Rab. Fl. Eur., p. 39.

Considerable diversity of opinion exists as to the habitat of this species. According to Kützing it belongs to the fresh water forms, having been found by him in rapid brooks. "In schnell fliessenden Bächen." Bac., p. 54. Still more precisely does Rabenhorst assign to it a fresh water habitat. "Hab. in rivulis Sporadice per totam Europam e planitie usque in regionem montanam superiorem, Fl. Eur., p. 39. While Smith gives it either a fresh water or brackish locality, Heiberg makes it a marine species. His remarks are worthy of notice. "Smith attributes the authorship of this species to Kützing, but Kützing's figure can hardly be identified with certainty, and seems to be more properly referrible to Melosira varians. Kützing's Melosira Jurgensii more nearly resembles Smith's species, and so Pritchard accepts it. But Pritchard calls the species Melosira Jurgensii, and represents Melosira subflexilis Sm. as a synonym; but in any case this ought to be reversed, inasmuch as Smith was the first to define the species so that it could be identified with certainty." "Smith assigns it to fresh water, but as the localities mentioned are near the mouths of rivers, the species possibly has been borne out along with the floods." De Danske Diat., pp. 28, 29. In addition, I have only to say that the localities in which the species has been found by me in Ireland are marine, but still liable to the access of fresh water.

Lough Foyle, Bellarena, Co. Derry. Greystones, Co. Wicklow.

Melosira varians, (Agardh.) Fresh water.

Ends of the frustules not so convex as in the preceding species.

Kütz. Bac., p. 54, T. ii., fig. 10. Rab. Die Süssw Diat., p. 13, T. ii., fig. 4. Wm. Sm. B.D., Vol. ii., p. 57, Pl. LI., fig. 332. Ralfs,

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* For explanation of contractions and list of references, *vide* List at end of Report.

in Pritch., p. 817, Pl. xv., fig. 32. Heiberg, De Danske Diat., p. 27.—Gallionella varians, Ehr. Inf. T. x., fig. 4.

Very common in streams and fresh springs.

Melosira distans, (Kutz.) Fresh water.

Frustules short, but slightly convex at the ends, distinctly punctate. (Pl. 26, fig. 3.)

Kütz. Bac., p. 54, T. ii., fig. 12. Rab. Die Süssw Diat., p. 13, T. ii., fig. 9. Wm. Sm. B.D., Vol. ii., p. 58, Pl. LXI., fig. 385. Ralfs, in Pritch., p. 818.—Gallionella distans, Ehr. Inf., p. 170, T. xxi., fig. 4.

Smith describes this species as "obscurely cellulate," and distinguishes it on this ground from his Melosira nivalis, which he characterises as "distinctly cellulate," but remarks that "this character is probably insufficient to justify their separation." B.D., Vol. ii., p. 58. The forms occurring in the Bilin Polirschiefer, one of the localities assigned by Kützing to Melosira distans, are most distinctly punctate; I am therefore disposed to consider that Smith's species, Melosira nivalis, cannot be sustained.

Killikee, Dundrum, Co. Dublin. Kilcool, Co. Wicklow. Pond near Armagh.

Genus II. LYSIGONIUM, Link.

Frustules globose or cylindrical, valves furnished with an elevated keel which runs parallel with the sutures; in other particulars as in Melosira.

I have adopted this genus in deference to the authority of Heiberg, who, referring to Lysigonium nummuloides, remarks, "This species, which by all the more recent authors has been assigned to the genus Melosira, in my judgment ought to constitute a type of a new genus to which Melosira Westii Wm. Sm., which does not occur in our country, may also be referred. The name Lysigonium was in the first instance applied by Link. to O. F. Muller's Conferva moniliformis, with which in all probability this species is identical; and for this reason it seems most convenient to re-establish the genus to receive it." De Danske Diat., p. 29. Heiberg further remarks, "that the known species form shorter or longer filaments, attached or free;" but I have never seen any of the filaments attached.

Lysigonium nummuloides, (Lyngbye, Kütz.) Marine.

Ordinary frustules, globose. Keel thin, in front view appearing as lines projecting like horns. (Pl. 26, fig. 4.)

Heiberg, De Danske Diat., p. 29.—Melosira nummuloides, Kütz.

Bac., p. 52, T. iii., fig. 3. Wm. Sm., B. D., Vol. ii., p. 55. Pl. xlix., fig. 329. Ralfs, in Pritch., p. 816, Pl. v., fig. 64 and Pl. xi., fig. 14.

There is considerable difference of opinion as to the founder of this species; Smith assigns it to Kützing, Ralfs to Dillwyn and Agardh. On this subject Heiberg says, "As above mentioned, O. F. Muller was probably the first to discover this species, and describe it under the name of Conferva moniliformis, or strand-necklace, but that cannot be ascertained with certainty. The present specific name is attributable to Dillwyn, who in 1809 described a Conferva nummuloides, which Lyngbye cites as a synonym under his Fragillaria nummuloides. But as meanwhile there do not appear to be any original specimens of Dillwyn's species, and his figures can only be approximately identified, while the numerous specimens of Lyngbye which still exist are all attributable to our species, it seems most proper to name Lyngbye as the author." De Danske Diat., p. 29.

Brackish ditch near Wexford, Malahide, Dollymount, North-wall, Co. Dublin. Salt ditch near Wicklow, and many other places too numerous to mention.

Lysigonium Westii, (Wm. Sm.) Marine.

Frustules somewhat conical, furnished with two keels, one at the suture, another near the end, considerably thicker than the similar structure in Lys. nummuloides, and not projecting upwards to the same extent.

Melosira Westii, Wm. Sm., B. D., Vol. ii., p. 59, Pl. lii., fig. 333. Ralfs, in Pritch., p. 817. Rab. Fl. Eur., p. 38.

Dollymount, Oyster beds, Howth, Co. Dublin. Near Wicklow. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Lysigonium Wrightii, (O'Meara.) Marine.

Frustules rounded at the ends, narrow, surrounded by a broad keel, which curving slightly outwards and upwards, then bending inwards and downwards to the surface of the valve, forms round it a crown-like rim. In the front view two nodules are observable in the central portion of the valve; the frustule is perfectly hyaline, without sculpture of any kind.

O'Meara, Q. J. M. S., Vol. ix., Pl. xii., fig. 3.

Arran Islands, Co. Galway.

Genus III. PODOSIRA, Ehr.

Filaments attached by a distinct stipes, and generally short, consisting of a few frustules.

Heiberg regards the character on which this genus is founded as "wholly destitute of a scientific basis." De Danske Diat., p. 27. Most other authors have, however, decided in favour of its validity. Smith's supposition that the apices of the valves are destitute of silex, with Heiberg and Ralfs, I consider is founded on imperfect observation.

Podosira Montagnei, (Kütz.) Marine.

Filaments usually consisting of two frustules. Frustules large, cylindrical, globose at the ends. (Pl. 26, fig. 5.)

Kütz. Bac., 52, T. xxix., fig. 85. Wm. Sm. B. D., Vol. ii., p. 53, Pl. xlix., fig. 326. Ralfs, in Pritch., p. 815, Pl. v., fig. 61. Rab. Fl. Eur., p. 37.

Arran Islands, Co. Galway.

Podosira hormoides, (Kütz.) Montagne. Marine.

Frustules small, compressed. Valve with distinct umbilicus, obscurely punctate.

Smith and Ralfs attribute the species to Kutzing; Heiberg, and Rabenhorst, Fl. Eur., to Montagne.

Kütz. Bac., p. 52, T. xxviii., fig. 5, and T. xxix., fig. 84. Wm. Sm., B. D., Vol. ii., p. 53, Pl. xlix., fig. 327. Ralfs, in Pritch., p. 815, Pl. ii., fig. 45. Rab. Fl. Eur., p. 37.—Melosira hormoides, Heiberg, De Danske Diat., p. 29.—Podosira nummuloides, Ehr.

Bannow, Co. Wexford. Salt ditch, near Wexford. Malahide. Piles on Strand, Clontarf, Co. Dublin.

Podosira maculata, (Wm. Sm.) Marine.

Frustules globose, distinctly punctate; puncta divided by radiate bands of a deeper colour, which latter do not reach the centre. Valves having a distinct umbilicus. (Pl. 26, fig. 5a.)

Wm. Sm., B. D., Vol. ii., p. 54, Pl. xlix., fig. 328. Ralfs, in Pritch., p. 815. Rab. Fl. Eur., p. 37.

Sea weeds, Bannow. Salt ditch, near Wexford. Arran Islands, Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Genus IV. Orthosira, Thwaites.

Frustules attached in filaments; without stipes, plane on the side view, ornamented with a circlet of puncta parallel with the suture; junction surfaces spinous.

The genus Orthosira was originally established by Thwaites, for the purpose of distinguishing the filamentous species with level end surfaces from those included in Melosira, the end surfaces of which are more or less arched, and thus defined it has been adopted by most succeeding authors. Ralfs and Rabenhorst, however, abandoning the generic distinction, have relegated the several species of Orthosira to the genus Melosira. Heiberg, on the contrary, recognises the distinction of Thwaites, but includes the species of Cyclotella in the genus Orthosira, and establishes a new genus, Paralia, to receive the single species Orthosira marina (Wm. Sm.), on the ground that the frustule possesses an elevated keel similar to that which characterises the genus Lysigonium. It is a question, then, whether the distinction of Thwaites should be recognised, as most authors since his time have done, or discarded, as Rabenhorst has considered it ought to be; and the following observations of Pfitzer seem to supply a reasonable solution. Having referred to the original distinction, he adds, "A far more important distinction exists in the mode of developing Auxospores. Although the Orthosiræ in their mode of growth agree thoroughly with Melosira, have the same structure of the primordial cell, and the same mode of cell-division, they differ in this respect, that in the process of spore-formation from a single cell, the valves of which are pushed away from one another, the contents enveloped in a mucous investment come out free, and are then, without being in contact with the mother-cell, developed into a single Auxospore in which the firstling cell is so situated that the plane of division crosses that of the mother-cell, whereas in Melosira it is parallel to it. Thwaites had observed this feature in the case of Orthosira aurichalcea, and Smith refers to the peculiarity as an important generic distinction. But only one species had been observed in this aspect, and so it was questionable whether all the Orthosiræ obeyed the same law. Fr. Schmitz has succeeded in proving this in respect to another species, Orthosira roeseana (Rab.), = O. spinosa (Grev.)" Ueber Bau und Entwicklung der Bac., p. 134. If then the mode of developing Auxospores be regarded, as I consider it ought to be, of importance as a generic distinction, the conclusion is inevitable that the genus Orthosira should not be merged in Melosira, as Ralfs and Rabenhorst have treated it. And also, forasmuch as in those species of Cyclotella in which the formation of Auxospores has been noticed, the daughter-cell is parallel to the mother-cell, for this reason, as well as on the old ground of distinction, the species of Cyclotella should not with Heiberg be included in the genus Orthosira.

Orthosira arenaria, (D. Moore.) Fresh water.

Frustules very large; cell-cavity sub-spherical. Spines on juncture surfaces short, broad, and close. Striæ, on side view punctate, radiate, stronger at the margin, and loosing their radiate arrangement as they approach the centre. Striæ on front view punctate, transverse. (Pl. 26, fig. 6.)

Wm. Sm., B. D., Vol. ii., p. 59, Pl. lii., fig. 334. Heiberg, De Danske Diat., p. 31. Ralfs, in Ann. N. Hist., Vol. xii., p. 349, Pl. ix., fig. 4.—Melosira arenaria, Kütz. Bac., p. 55, T. xxi., fig. 27. Rab. Süssw. Diat., p. 14, T. ii., fig. 5.

Besides the localities specified by Smith, namely, near Belfast and Lough Mourne deposit, I have found the species in the following places:—River Erne, Crossdoney, Co. Cavan; ditch near Wexford; Verner's-bridge, Co. Armagh; Killakee, Co. Dublin; stream near Kilcool, Co. Wicklow; L. Neagh, near the town of Antrim; surface of rock near Glenarm, Co. Antrim.

Orthosira sulcata, (Ehr. Kütz.) Marine.

Spines of junction surfaces large, short, and more distant than in the former species. Striæ on side view linear, radiate, distinct at the margin, attenuated towards the centre, which they do not reach; puncta at the suture large; striæ on front view linear, direct, parallel (Pl. 26, fig. 7.)

Melosira sulcata, Kütz. Bac., p. 55, T. ii., fig. 57. Ralfs, in Pritch., p. 819; Pl. ix., fig. 131; Plate xi., fig. 26. Rab. Fl. Eur. p. 41.—Orthosira marina, Wm. Sm., B. D., Vol. ii., p. 59; Pl. liii., fig. 338.—Gallionella sulcata, Ehr.—Paralia marina, Heiberg, De Danske Diat., p. 33.

Although this species has been described and figured by Kützing as identical with Gallionella sulcata of Ehrenberg, Heiberg attributes it to Wm. Smith. The latter indeed has figured it more perfectly than Kützing has done; still, Kützing's figure, imperfect as it is, seems to me unmistakable; and all uncertainty as to the species indicated is removed by his reference to the Richmond deposit in which the form abounds. For this reason I have followed Ralfs and Rabenhorst in assigning the species to Ehrenberg and Kützing, as well as restoring the original specific designation. And as I have not been able to trace any keel similar in structure and position to that of Lysigonium, instead of adopting Heiberg's new genus, Paralia, I leave the species where Smith placed it in the present genus.

Cork and Kinsale Harbours, Wm. Smith. Bannow, River Slaney, Killurin, Co. Wexford. Near Wicklow. Malahide. Dalkey, Co. Dublin.

Orthosira Dickieii, (Thwaites.) Fresh water.

Cell-cavity sub-spherical. Sutural puncta small and distant. Spines on junction surfaces absent. Striæ, both on front and side view, minutely punctate. Puncta on front view arranged in lines parallel to the suture.

Thwaites, Ann. N. H., 2 series, Vol. i., p. 168, Pl. xii. Wm. Sm., B. D., Vol. ii., p. 60, Pl. lii., fig. 335.—Melosira Dickieii, Kütz. Sp. Alg., p. 889. Ralfs, in Pritch., p. 820, Pl. xv., fig. 29. Rab. Fl. Eur., p. 43.

This species is remarkable for the abnormal growth of frustule within frustule, so fully described by Smith, B. D., Vol. ii., Pl. lii., fig. 335. Thwaites regarded this peculiarity as a mode of developing sporangia, while Smith considered it an abnormal development similar to what he had noticed in Meridion circulare and M. constrictum, Himantidium Soleirolii, Odontidium anomalum, and Achnanthes subsessilis. I add the interesting description given by Pfitzer of an anomalous procedure noticed by Fr. Schmitz in the development of Orthosira spinosa, as likely to throw some light on the subject. "A separation of the firstling-cell followed, not immediately, but a deviation occurred analogous to what has been described in the case of Navicula ambigua. First one girdleband was developed, the length of which was about that of the radius of the cell. This girdleband, according to Fr. Schmitz, was attached only to one valve; that which ought to have been connected with the other valve, if it existed at all, was only rudimentary. Then the plasm moved about only in that half of the cell to which the girdleband adhered, and secreted a new valve, which, as might be expected, was parallel to the original one destitute of the girdleband. In the cell so originating, division then took place in the normal manner, only that the one end-cell of the filament in course of formation, instead of two valves possessed three. Inasmuch as a small portion of the plasm remained behind, between the two parallel valves, and then died off, Fr. Schmitz was inclined to think the procedure was an abortive attempt at self-division, one portion of the plasm being too small to develop itself into a daughter-cell." Ueber Bau und Entwicklung der Bac., p. 135.

Ditch on bank of Royal Canal, near Kilcock, Co. Kildare. It is likely this species is more common than it appears from the few localities assigned to it, as in its normal condition it may be easily confounded with Melosira varians.

Orthosira orichalcea, (Wm. Sm.) Freshwater.

The circle of puncta that in most of the species of this genus runs parallel with the suture is not observable in this. Spines on junction surfaces distinct; valve not striated on the side view, except on the margin, where the points of the spines appear as small puncta. Frustules striated on front view. Striæ fine, punctate, parallel. (Pl. 26, fig. 8.)

Ralfs and Rabenhorst have referred this species to Mertens on the authority of Kützing, who has figured and described a form under this specific designation. The figure of Melosira orichalcea, Bac., T. ii., fig. 14, is by no means definite, and one feature in the description suggests the impression that he had quite a different species in view. "Sub epidermide silicea leviter bis contractis," Bac. p. 54, may possibly refer to Orthosira spinosa, but not to Orthosira orichalcea, as figured by Smith, to whom Heiberg considers the species should be attributed, as he was the first to give a description and figure by which it could be satisfactorily identified. Heiberg makes the following shrewd observation under Orthosira orichalcea :—"The figure by which Smith describes the process of conjugation in the species under consideration, and which he copied from Thwaites' original delineation, deviates so much from the normal appearance of the species, that one may almost take it for certain that it represents a very different form, for a difference of so much importance could scarcely have arisen from inadvertence."—De Danske Diat., p. 31. In Thwaites' original description of Aulocoseira crenulata, Kütz. = Melosira orichalcea, Ralfs (and Orthosira orichalcea, Wm. Sm.), both the generic definition and the figure are inapplicable to the present species as figured by Smith. "*Aulacoseira* cellulis cylindricis, *bisulcatis*, extremitatibus plus minusve rotundatis, in filamenta concatenatis." Ann. of Nat. Hist. March, 1848, p. 7, most correctly describes Orthosira Roeseana, Rab. = O. spinosa (Wm. Sm.). The frustules, as described ib. Pl. xi., B., figs. 1, 2, and 3, are greatly more like that form than any other species, and the side view, as represented in the sporangial frustule, is precisely as the side view of that species is described by Smith, B. D., Vol. ii., p. 62, Pl. lxi., fig. 386. I am therefore disposed to think that it was not Orthosira orichalcea, but Orthosira Roeseana, which Thwaites observed in the process of forming sporangia, or, as Pfitzer designates them, Auxospores.

Smith's Irish localities are—Well at Seven Churches; Clonmacnoise; Moanarone, County Cork; Lough Mourne deposit; to which I have to add the following:—River Erne, Crossdoney, County Cavan; Lough Islandreavy, County Down; Lough Neagh, near the town of Lurgan, County Armagh; Killakee and Glenchree, County Dublin.

Orthosira punctata, (Wm. Sm.) Fresh water.

This species is distinguished from the preceding chiefly by the fact that in this the puncta are very much larger, and more regularly arranged; they are parallel to the suture, and so regularly placed that they sometimes appear to run spirally. Heiberg remarks that "Smith's species is easily recognised by the obvious rows of puncta crossing one another, which run in oblique spirals from the suture up to and over the side view."—De Danske Diat. p. 31. These last words seem to imply that the side view is punctate like the front view; if so, then the species must be regarded as certainly distinct from the preceding. Smith does not figure the side view, and, in consequence of the length of the frustule, it is difficult to turn it over so as to get it under observation. In one case only could I get a view of it, and then only obliquely; in this aspect it appeared strongly punctate. The circle of spines at the suture is absent in this species as in the last.

Ralfs, in Pritchard, p. 820, makes this species synonymous with Melosira granulata = Gallionella granulata, Ehr. and Rabenhorst, Fl. Eur., p. 43, adopts the same course; but so much uncertainty characterises Ehrenberg's figures of that species, I prefer, with Heiberg, to adopt the precise figure of Smith, and attribute the species to him.

Ulster Canal, near Poyntzpass. Lough Neagh, near Lurgan, County Armagh.

Orthosira Roeseana, (Rab.) Fresh water.

Inner surface of cell sub-spherical; frustule sulcate on either side of suture; spines at the junction surfaces very distinct and long; circlet of puncta parallel with suture absent. Striæ on side view radiate, distinct, with three large puncta placed triangularly at the centre. On front view striæ finely punctate, and parallel with suture. (Pl. 26, fig. 9.)

Smith, in 1856, describes this species as new, under the name of Orthosira spinosa. Wm. Sm., B. D., Vol. ii., p. 62, Pl. lxii., fig. 386. But it had been already described by Rabenhorst, Süssw. Diat., p. 13, T. x., fig. 5, in 1853, as Melosira Roeseana, and with sufficient accuracy, both as respects the figure and the description, as to render identification certain. Melosira Roeseana, Ralfs, in Pritch., p. 818, Pl. v., fig. 67.

Killakee, County Dublin. Ulster Canal, near Poyntzpass. Lough Neagh, near Lurgan, County Armagh. Ditch at side of Royal Canal, near Kilcock, County Kildare.

Genus V. CYCLOTELLA, Kütz.

Frustules normally single, narrow; sometimes slightly waved on the front view; on the side view having the valves more or less distinctly divided into two concentric portions.

It is extremely difficult to define this genus by words so precisely as to distinguish it with certainty from others nearly allied; yet still the forms included within it constitute a tolerably distinct group. So much so, that almost all authors have agreed to mark their peculiarity by a distictive generic name.

Heiberg and Cleve have included the several species under the genus Orthosira, with which they are closely allied; but I consider them entitled to stand by themselves, not only on account of their different modes of growth, but also on account of the distinctive characters of their sporangia.

It would appear at first view that the generic name Discoplea should, on account of its priority, be preferred to the more recent name of Cyclotella. As Ehrenberg has given no verbal diagnosis of his genus Discoplea, we have no means of ascertaining its characteristics, otherwise than by the figures, and in these no sufficiently distinctive feature is discernible. Not only are forms that seem to belong to different species included under the same specific name, but more than this, species belonging to Orthosira, on the one hand, and more closely resembling Coscinodiscus, on the other, are included in the genus Discoplea. Kützing's diagnosis of his genus Cyclotella, although sufficient to distingush it from Orthosira, on the one hand, is not clear enough, so far as words are concerned, to prevent confusion with Coscinodiscus, on the other. Yet his figures, however obscure in minute details of structure, distinctly mark the separation of the valves into two well-defined concentric parts.

Walker-Arnott confounded the distinction between this genus and Orthosira, when he identified Cyclotella dallasiana with the Cyclotella radiata of Brightwell, which should rather be included in Orthosira. There is great confusion as to the synonomy of the several species; nor is this surprising, as the earlier descriptions and figures are by no means satisfactory; and, in order to avoid consequent perplexity, I consider there is no more satisfactory plan than to follow the line marked out by the figures of Wm. Smith, which are so distinct as to be easily recognised.

Cyclotella Kützingiana, (Thwaites.) Fresh water.

Frustules undulate; striæ delicate, marginal, scarcely one half of the radius in length; the central portion of the valve unstriate. (Pl. 26, fig. 10.)

Smith attributes this species to fresh or brackish water, and with this opinion Rabenhorst concurs. Walker-Arnott alleges he has never seen the true species from fresh water. Cleve makes it an essentially brackish water species, and Heiberg on the contrary, a fresh water form. This difference of opinion may arise from mistake as to identity; but speaking of the form described by Smith as C. Kützingiana, I have to say that though I have sometimes found it in water slightly brackish, it has been commonly discovered by me in localities far remote from marine influences, so that I think it is to be considered an essentially fresh water species.

The slightly undulate outline which this species presents on the front view may possibly arise from the sinking in of the valve in the centre, and the consequent projection of the outline of the dip upon the plane of observation. Thus Wm. Smith accounts for the appearance, and his opinion on the subject is supported by that of Heiberg.

Wm. Sm., B.D., Vol. i., p. 27, Pl. v., fig. 47. Raben. Fl. Eur., p. 32.—Orthosira Kützingiana, Heib. De Danske Diat., p. 31.

Stream, Crossdoney, Co. Cavan. Stream near Larne, Co. Antrim. Tacumshane, Co. Wexford. Ditch on banks of River Liffey, Co. Kildare, near Ballymore Eustace. Tarbert, Co. Kerry. Ditch, Kilcool, Co. Wicklow.

Cyclotella Meneghiniana, (Kütz.) Fresh water.

Frustules not undulate on the front view; striæ on the valves much coarser than in the former species, more distant, and considerably longer. (Pl. 26, fig. 11.)

Walker-Arnott regards this species as identical with C. rectangula, De Brèb, and the greater weight attaches to his opinion as it was adopted after examination of specimens "from De Brèbisson himself, and a portion of the only gathering he ever made of it (near Paris.)" Q. J. M. S., Oct., 1860, p. 245. Subsequently De Brèbisson found the same form at Falaise, and gave a figure of it which is confirmatory of the opinion of Walker-Arnott. "Notes on some French Diatomaceæ," Journal of Queckett Mic. Club for April, 1870, fig. 6. Kützing states that this species is adnate. I have never seen it so.

Kütz. Bac., p. 50, T. xxx., fig. 68. Rab. Süssw. Diat., p. 11. T. ii., fig. 2. Possibly this species may be identical with C. Kützingiana, var. B. Wm. Sm., B. D., Vol. i., p. 27; and if so, it is not the same that Ralfs has figured as C. rectangula (De Brèb.) Ralfs, in Pritch., Pl. v., fig. 54; the latter being undulate on the front view, whereas the present species is rectangular.

Lucan. Feather-bed mountain, Co. Dublin. Kilcool, Co. Wicklow.

Cyclotella operculata, (Kütz.) Fresh water.

Marginal striæ short, fine, linear; central part of valve covered with distinct moniliform striæ radiately arranged. (Pl. 26, fig. 12.)

Though Smith, who is followed by Ralfs, describes the striæ in this species as obscure and very short, the figure in both cases is too clear to admit of any doubt as to identification.

Kütz. Bac., p. 50, T. i., figs. 1, 12, and 15. Wm. Sm., B. D., Vol. i., Pl. v., fig. 48. Ralfs, in Pritch., p. 811, Pl. v., fig. 53.—Orthosira operculata, Heiberg, De Danske Diat., p. 32. Cleve, Om Svenska och Norska Diat., p. 217. This form is not identical with that described by Walker-Arnott under this name, with the centre destitute of striæ, but probably is the same as the variety he identifies with C. minutula, Kütz. See Arnott on Cyclotella, Q. J. M. S. for Oct., 1860, pp. 246, 247.

Lower Lake, Killarney, Co. Kerry. Derrylane Lake, Co. Cavan. Glenchree, Co. Wicklow. River Bann, near Coleraine, Co. Derry. River Erne, Crossdoney, Co. Cavan. Royal Canal, Enfield, Co. Meath. Lough Neagh, near Lurgan, Co. Armagh. Lough Mourne deposit. Lough Island-Reavy deposit, found also living in the same place.

Cyclotella operculata, var. Fresh water.

Margin of valve fringed with short rounded distinct costæ, over which there is a circle of very fine linear striæ, short; centre of the valve as in the former, but the moniliform striæ much finer and more obscure. (Pl. 26, fig. 12, b.)

On banks of the Liffey, near Ballymore Eustace, Co. Kildare. Lough Neagh, near Lurgan, Co. Armagh.

Cyclotella antiqua, (Wm. Sm.) Fresh water.

Marginal portion of the valve narrow, marked with short, broad, triangularly formed bars, over which there is a circlet of very fine short linear striæ; central portion occupied by about nine triangular bars which do not reach the centre. (Pl. 26, fig. 13.)

Smith does not figure the fine marginal striæ, and describes the marginal triangular bars as if they were moniliform; but with this exception his figure is in every respect accurate, so as to remove all doubt as to the identity of the species. Walker-Arnott considers that Smith's form is identical with C. minutula, Kütz., found by him in the Lüneburg deposit, and adds, "It is this which Smith obtained from the Lough Mourne deposit, but which he has unfortunately referred to C. antiqua, a species which does not occur in any of the Irish deposits which I have examined." On Cyclotella, Q. J. M. S., Oct., 1860, p. 246. The forms of Cyclotella found on the only slide I possess from the Lüneburg deposit are those of C. operculata. Walker-Arnott evidently had not seen any specimen of C. antiqua, for the distinctiveness of the species is too obvious to have escaped his keen observation, had even a single form of it come under his notice.

Wm. Sm., B. D., Vol. i., p. 28; Pl. v., fig. 49. Ralfs, in Pritch., p. 812. Rab. Fl. Eur., p. 33.

Lough Mourne deposit, in which I have occasionally noticed it. Sub-peat deposit, Dromore, Strangford Peat, Co. Down.

Cyclotella rotula, (Kütz.) Fresh water.

Valve with a slight depression towards the centre, striæ radiate, running from the margin to the centre; coarse at the margin, finer and finer as they approach the centre, where they appear confused. Striæ linear, but notched, so as to seem moniliform. (Pl. 26, fig. 14.)

In consequence of supposing that Discoplea rotula of Ehr., Mic., T. xxxv. A. xxii., fig. 67, was a species of Cyclotella, Kützing, in his Species Algarum, changed his original specific name to that of Cyclotella astræa, and this nomenclature has been adopted by Ralfs and Rabenhorst. It is not, however, certain that Ehrenberg's form properly belongs to Cyclotella, and therefore the original name ought to be retained.

Kütz. Bac., p. 50, T. ii., fig. 4. W. Sm., B. D., Vol. i. p. 28; Pl. v., fig. 50. Walker-Arnott, Q. J. M. S., Oct., 1860, p. 247.—Cyclotella astræa, Ralfs, in Pritch., p. 812. Rab. Fl. Eur., p. 34.—Orthosira rotula, Heiberg, De Danske Diat., p. 32. Cleve, Om Svenska och Norska, Diat., p. 217.

Lough Neagh, in several parts. Lucan, Feather-bed mountain, and Grand Canal, Co. Dublin. River Bann, near Coleraine, Co. Derry. Lough Mourne and Lough Island-Reavey deposits. Small forms of this species may be, at first view, readily mistaken for Cyclotella operculata, but on close inspection the difference will be obvious.

Cyclotella papillosa, (N. S.) Fresh water.

Marginal striæ of the valve linear, very fine, central portions unstriate and occupied by a circlet of papillæ, usually five or six in number. (Pl. 26, fig. 15.)

There is a form resembling the present, described by Ehrenberg as Discoplea atmospherica, from Nepal, Mic., T. xxxii. v., fig. 4; and also from Fayoom, Egypt, Mic., T. xxxii. i., fig. 3; but as the figures of Discoplea atmospherica differ so widely from one another, even if there were no doubt as to the identity, a different name is needful to mark the peculiarity of the present species.

Lough Neagh, near Lurgan, Co. Armagh. Lough Mask, near Tourmakeady, Co. Mayo. There is a form occurring in the Lough Mourne deposit, which may be the same as this, but the papillæ are usually injured, and, judging from the traces that remain, they seem to have been more numerous, more slender, and more scattered than in the living forms.

Cyclotella Scotica, (Kütz.) Marine.

Valve very small, finely striate on the margin; the centre unstriate. Kütz.

Bac., p. 50, T. i., figs. 2 and 3. Ralfs, in Pritch., p. 811. Pl. xiv., fig. 17. (Pl. 26, fig. 16.)

On sea-weeds at the Giants' Causeway, Co. Antrim. Kützing and Ralfs describe this species as adnate, but as my specimens had been treated with acid before observation, I cannot confirm this character.

Cyclotella dallasiana, (W. Sm.) Marine.

Margin of the valve coarsely striate; central part rugose, as if blistered. Smith represents the central part as "cellulate;" but Walker-Arnott has more accurately described it as "puckered, or as if blistered."

Wm. Sm., B. D., Vol. ii., p. 87. Walker-Arnott, Q. J. M. S, Oct., 1860, p. 245. Ralfs, in Pritch., p. 813. Rab. Fl. Eur., p. 33.

Stomachs of Ascidians. Roundstone Bay, Co. Galway.

Cyclotella punctata, (Wm. Sm.) Fresh water.

Frustules undulate on front view; on side view, striæ close, radiate, very finely punctate, puncta smaller towards the margin, which latter is surrounded by a circlet of short, fine costæ. (Pl. 26, fig. 17.)

Wm. Sm., B. D., Vol. ii., p. 87. Ralfs, in Pritch., p. 813. Pl. viii., fig. 13. Rab. Fl. Eur., p. 33.

Lough Island-Reavey, Co. Down. Float bog, Co. Westmeath.

Genus VI. Coscinodiscus, Ehr.

Frustules simple, free, lenticular; valve generally uniformly striate. Striæ areolate or moniliform. Without processes or undulations.

Kützing noticed the close affinity between Melosira and the present genus, but in his classification placed them very widely apart, simply because in the latter the striation was, as he describes it, areolate. But subsequent writers found this distinction untenable, inasmuch as in Creswellia, connected with Melosira by the filamentous character of its frustules, the striation is distinctly areolate, while in some of the species which are properly included in the genus Coscinodiscus the areolate character disappears.

Heiberg is dissatisfied with the diagnoses which preceding authors have given, but in consequence of the limited amount of material for observation at his command, declines to attempt a more satisfactory definition. It appears to me that if Coscinodiscus excentricus, which is described as having a spinous or dentate margin, be excluded, we shall then have a tolerably well-marked group, as above defined.

(a) *Disk with a central rosette.*

Coscinodiscus oculus iridis, (Ehr.) Marine.

Central rosette, consisting of from six to nine large oblong cellules. Cellules large, hexagonal, radiate, distinctly smaller as they approach the margin. (Pl. 26, fig. 18.)

Ehr. Mic., T. xviii., fig. 49. Ralfs, in Pritch., p. 828. Raben. Fl. Eur., p. 34. Heiberg, De Danske Diat., p. 35. Cleve, Om Svenska och Norska Diat., p. 217.

Tide pool, Monkstown; on sea-weeds, Ballybrack; tide pool, Dalkey; Oyster-shells, Dublin Bay, all in the County Dublin.

Coscinodiscus centralis, (Ehr.) Marine.

Central rosette consisting of about eight large rounded cellules surrounding a single central one. Cellules distinctly hexagonal, radiate, nearly equal, and smaller than in the former species. (Pl. 26, fig. 19.)

Ehr. Mic., T. xviii., fig. 39. Greg. Diat. of Clyde. p. 28, Pl. xi., fig. 49. Ralfs, in Pritch., p. 828. If Gregory describes and figures with accuracy the form so named, and found by him in Glenshira Sand, as well as in the Clyde, it can scarcely be identical with the present species. The only difference, however, is in the character of the cellules forming the central rosette, which, in his form, consists of "three large oblong cells meeting in a point, and between these, a little farther from the centre, three more cells, a little smaller." Ralfs, however, as above cited, describes this portion of the valve as consisting of "a few oblong cellules, round a circular one;" which description accurately represents the appearance of the rosette in the present form, and therefore I adopt the specific name.

On sea-weeds, Ballybrack, Dalkey, Co. Dublin. Stomachs of Ascidians, Belfast Lough.

Coscinodiscus stellaris, (Roper.) Marine.

Central rosette, consisting of five or six long and narrow cellules; striæ extremely minute, punctate, radiate.

Roper, Q. J. M. S., Vol. vi., p. 21, Pl. iii., fig, 3. Ralfs, in Pritch., 828, Pl. v., fig. 83.

Oyster Shells, Dublin Bay.

Coscinodiscus concinnus, (Wm. Sm.) Marine.

Central rosette, consisting of from three to eight large flattened cellules. Cellules small, radiate; valve divided into compartments by radiating lines, which do not reach the margin.

Wm. Sm., B. D., Vol. ii., p. 84. Roper, Q. J. M. S., Vol. vi., p. 20, Pl. iii., fig. 12. Ralfs, in Pritch., p. 828. Roper, as above cited, states that "the larger specimens show plainly a point that is not easily discernible in those under ·004″ in. diameter, namely a submarginal row of minute spines, varying from $\frac{1}{3000}$th to $\frac{1}{4000}$th of an inch apart, according to the size of the disk, and from each of which there is a radiating line almost to the centre of the valve." I have, in consequence, considerable hesitation in including the species under the genus Coscinodiscus; but, as the specimens that came under my notice were few in number, and in every case imperfect, I would not presume to make any change in the position to which it has been assigned.

It was found by Wm. Sm. in Kinsale Bay, and fragments have occurred on sea-weeds, Ballybrack, and on oyster-shells from Dublin Bay, both in the County Dublin.

(b). *Disk with a central hyaline space like a perforation.*

Coscinodiscus perforatus, (Ehr.) Marine.

Hyaline centre, small, surrounded by about five rounded cellules. Cellules large, indistinctly hexagonal, radiate, decreasing in size near the margin. (Pl. 26, fig 20.)

Smith describes the cellules as "equal," and Ralfs as "minute;" but in my specimens they differ as stated above.

Ehr. Mic., T. xviii., fig. 46. Wm. Sm., B. D., Vol. ii., p. 85. Ralfs, in Pritch., p. 829.

From stomachs of Howth Oysters, Tide-pool, Monkstown, Dalkey, Ballybrack; on Oyster shells, Dublin Bay. Stomachs of Ascidians, Belfast Bay.

(c). *Disk without a central rosette or vacant space. Cellules radiate.*

Coscinodiscus gigas, (Ehr.) Marine.

Disk very large, cellules not very large, hexagonal, radiate, smaller towards the centre. (Pl. 26, fig. 21).

Ehr. Mic., T. xviii., fig. 34. Kütz. Bac., p. 132, T. i., fig. 16.

Stomachs of Ascidians, dredged on the coast of County Clare.

Coscinodiscus radiatus, (Ehr.) Marine.

Cellules large, hexagonal, radiate, somewhat smaller near the margin.

Ehr. Mic., T. xx., fig. 1. Kütz. Bac., p. 132, T. i., fig. 18. Wm. Sm., B. D., Vol. i., p. 23, Pl. iii., fig. 37. Ralfs, in Pritch., p. 830, Pl. xi., figs. 39 and 40. Heiberg, De Danske Diat., p. 36. Cleve, Om Svenska och Norska Diat., p. 218. Rab. Fl. Eur., p. 34.

On sea-weeds, Bannow, County Wexford. Piles of wooden bridge, Dollymount; Malahide. Stomach of Pectens, Dalkey. On corallines, Howth. On sea weeds, Ballybrack, County Dublin. On sea weeds, Kilkee, County Clare. From stomachs of Ascidians, coast of County Clare.

Coscinodiscus radiolatus, (Ehr.) Marine.

Disk small, cellules minute, obscurely hexagonal, arranged partly in radiate bands, and partly in the intervals of these bands in converging lines. Cellules confused at the centre of the disk, smaller towards the margin. (Pl. 26, fig. 22.)

Kütz. Bac., p. 132, T. xxix., fig. 91. Ralfs, in Pritch., p. 830, who describes the form thus:—"Cellules punctiform, equal, radiating," whereas, in fact, they are minutely hexagonal, and diminish slightly near the margin.

Oyster shells, Dublin Bay. Tide-pool, Dalkey, County Dublin. Stomachs of Ascidians, Roundstone Bay, County Galway. Stomachs of Ascidians, County Clare.

Coscinodiscus cervinus, (Brightwell.) Marine.

Cellules very minute, radiate, close, dry valve fawn-coloured, frustule convex.

Brightwell has described and figured this form as Hyalodiscus cervinus, Q. J. M. S., Vol. viii., p. 95, Pl. vi., fig. 13. He describes the "puncta or dots" as "scattered over the whole surface;" but in his figure represents them as regularly radiate, which latter corresponds exactly with my specimens. Ralfs, in Pritch., p. 831, places the form among the doubtful species of Coscinodiscus, to which genus it properly belongs.

From stomachs of Ascidians, Roundstone Bay, County Galway. From stomachs of Ascidians, County Clare.

Coscinodiscus Smithii, (Wm. Sm.) Fresh water.

Disk small, punctate, puncta regularly radiate.

Wm. Sm., B. D., Vol. i., p. 23, Pl. iii., fig. 36.

Smith has unaccountably confounded this form with Coscinodiscus minor, Ehr., from which it is plainly distinguished, both by its habitat and the character of the striation; the latter being marine and areolate, the former a fresh water species, and punctate.

Ralfs, in Pritch., p. 818, considers this form may be identical with Melosira nivalis, but it plainly belongs to the genus Coscinodiscus.

Lough Neagh, near Lurgan, County Armagh. Lough Island-Reavey, County Down. River Blackwater, near Kells, County Meath.

Coscinodiscus Normanni, (Greg.) Marine.

Cellules on the the disk small, obscurely hexagonal, radiate, arranged in fascicles of about six lines, decreasing in size as they approach the margin ; valve very convex in the centre.

Greville, Q. J. M. S., Vol. vii., p. 81, Pl. vi. fig. 3. Ralfs, in Pritch., p. 830.—Coscinodiscus fasciculatus, O'M., Q. J. M. S., New Series, Vol. vii., p. 249, Pl. vii., fig. 1.

Arran Island, County Galway. Stomachs of Ascidians, Roundstone Bay, County Galway.

Coscinodiscus nitidus, (Greg.) Marine.

Margin of the disk striated, cellules distant, roundish, large, distinctly radiate, except near the centre, where they are slightly confused. Smaller at the margin, gradually increasing in size towards the centre.

Greg. Diat. of Clyde, p. 27, Pl. x., fig. 45. Ralfs, in Pritch., p. 833, Pl. viii., fig. 18.

Arran Island. Stomachs of Ascidians, Roundstone Bay, County Galway. Malahide, County Dublin. Rostrevor, County Down. Kilkee, County Clare.

Coscinodiscus Gregorii, N. S. Marine.

Margin of the disk striated, cellules sub-quadrangular, much smaller than in the former species, and more equal in size, radiate; a small vacant angular space in the centre, from the angles of which so many lines of cellules run to the margin, the interspaces filled up by rows of cellules, gradually shortening. (Pl. 26, fig. 23.)

Gregory, Diat., from Glenshira Sand, Q. J. M. S., Vol. v., Pl. i., fig. 50. After describing Coscinodiscus nitidus, Gregory remarks, "this pretty disk was figured, without a name, in my last Paper on the Glenshira Sand (Trans. Mic. Soc., Vol. v., Pl. i., fig. 50). Having found it tolerably frequent in Lamlash Bay, I now figure a perfect example, which provisionally I refer to Coscinodiscus." Diat. of Clyde, p. 28. This form may easily be confounded with the preceding, as Gregory has done ; but a more careful comparison of the many specimens that have come under my observation convinces me the forms are distinct; and accordingly I give to the present the name of Gregory, who first discovered it.

Arran Island. From stomachs of Ascidians, Roundstone Bay, County Galway. Stomachs of Ascidians, County Clare.

(d). *Cellules radiate at the margin, linear in the central portion.*

Coscinodiscus fimbriatus, (Ehr.) Marine.

Cellules hexagonal; small; in the central portion of the disk arranged in lines crossing in quincunx; towards the margin radiate; smaller towards the margin.

Ehr. Mic. Ralfs, in Pritch., p. 829.

Stomachs of Ascidians, County Clare.

(e.) *Cellules arranged variously.*

Coscinodiscus marginatus, (Ehr.) Marine.

Cellules large, hexagonal, arranged in irregularly curved lines, with a distinct narrow strongly costate margin.

Ehr. Mic. Ralfs, in Pritch., p. 829. Weisse, Recherches Microscopique sur le Guano, Bul. de l'Academie Imp. de St. Petersburg, T. xii., p. 122, Pl. i., fig. 21.

Stomachs of Ascidians, Roundstone Bay. Arran Islands. Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Coscinodiscus lineatus, (Ehr.) Marine.

Cellules rounded, arranged in oblique, parallel lines.

Ehrenberg, in his Microgeologie, gives several figures under this name. One of them, T. xxii., fig. 6 a. b., seems scarcely assignable to the genus Coscinodiscus, inasmuch as it is furnished with a marginal circlet of nodules. Besides this there are two other forms, quite distinct: one in which the striæ are linear, to be immediately described; the other, the present form, which is furnished with cellules as described above.

Ehr. Mic. Kütz, Bac., p. 131, T. i., fig. 10. Ralfs, in Pritch., p. 830.

Malahide. Monkstown. Dredgings in Bay, Co. Dublin. Seaweeds, Wicklow. Breaches near Newcastle, Co. Wicklow. Bannow, Co. Wexford. Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway.

Coscinodiscus Ehrenbergii, N. S. Marine.

Disk striate. Striæ linear, in two series, crossing each other obliquely. (Pl. 26, fig. 24.)

This is the form described by Ehrenberg as Cos. lineatus, Mic., T. xxxv., A. 17, fig. 7; T. xxxv., A. 16, fig. 3. Weisse, Bul. de l'Academie de St. Petersburg, Tom. xii., Pl. i., fig. 20 a.

Malahide. Piles of wooden bridge, Dollymount, Co. Dublin. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Coscinodiscus minor, (Ehr.) Marine.

Disk small. Cellules roundish, without any perceptible arrangement. (Pl. 26, fig. 25.)

Ehr. Mic., T. xviii., fig. 31; T. xx.-i., fig. 28; T. xxii., fig. 27; T. xix., fig. 3. Kütz. Bac., p. 131, T. i., figs. 12, 13. Ralfs, in Pritch., p. 831. Weisse, Recherches Microscopiques sur le Guano, Bul. de l'Academie Imperial de Science de St. Petersburg, T. xii., p. 121, Pl. i., fig. 22.

Tide-pool, Dalkey, Co. Dublin.

Coscinodiscus punctulatus, (Greg.) Marine.

Striæ indistinct. Disk covered with what appear to be fine puncta, irregularly scattered.

Gregory describes the disk in his specimens as "marked by very fine and obscure lines, which, near the margin, are traceable as rays, but which soon become fainter, and apparently wavy, at the same time as they proceed towards the centre."—Diat. of Clyde, p. 28.

Several specimens, from different localities, came under my notice, but all mounted in balsam. In consequence I could not trace the lines referred to; and, moreover, the puncta in such forms as were seen obliquely had the appearance of fine hairs. This circumstance increases the doubt which I entertain, in common with Gregory and Ralfs, as to whether the form is properly referred to the genus Coscinodiscus.

Gregory, Diat. of Clyde, p. 28, Pl. x., fig. 46. Ralfs, in Pritch., p. 831.

Arran Islands. From stomachs of Ascidians, Roundstone Bay, Co. Galway. On Fucus serratus, Ballybrack, Co. Dublin.

Genus VII. ARACHNOIDISCUS, Ehr. Deane.

Arachnoidiscus Ehrenbergii, (Bailey.) Marine.

"Disk with a central hyaline nodule or umbilicus, and numerous radiating lines, connected by concentric circles of large pearly granules; the circle next the umbilicus formed of short lines."—Ralfs.

Wm. Sm., B. D., Vol. i., p. 25; Supp. Pl. xxxi., fig. 256. Ralfs, in Pritch., p. 842, Pl. xv., figs. 18–21.

This truly splendid form has been discovered in the fossil earths of California, and in a living state it has been gathered in Japan, California, and South Africa. It is its habit in congenial climates to cover completely the plants to which it is attached. It admits of serious doubt, therefore, whether the few isolated specimens which have been discovered in this kingdom entitle it to be included among our British forms. Rabenhorst does not give it a place among the European species of Diatomaceæ; and perhaps he was right in excluding it. But it seems desirable to notice the fact of its having been found. Besides the case mentioned by Smith, Captain Hutton found some two or three specimens in a gathering made by him at Malahide, Co. Dublin, as mentioned in the Proceedings of the Dublin Microscopical Club, 15th December, 1864; Q. J. M. S., April, 1865, p. 167. Had these forms been found in the proximity of a harbour resorted to by foreign vessels, it might be suspected they were imported from foreign seas, and deposited as the vessels unladed their freight; but such a supposition cannot be entertained regarding Malahide. I was present at the meeting when the specimens were exhibited, and remember that Captain Hutton informed me that he had not been working with any material likely to contain these forms, and that he was confident they were taken from the sea at Malahide, as the vessels used in the preparation were new, and had not been used before. I have myself to add, that a single frustule was recently found by me in a gathering made by Rev. M. H. Close, at a place called Drehidnamaud, on the coast of the Co. Kerry.

In the same gathering which yielded the specimens of Arachnoidiscus Ehrenbergii, Captain Hutton found some specimens of what he regarded as Arachnoidiscus ornatus; but considering it likely these latter were not specifically distinct, I only refer here to the circumstance as corroborative of the probability that Arachnoidiscus Ehrenbergii was found at Malahide.

Genus VIII. Craspedodiscus, Ehr.

Disk not undulate, having a broad border, with areolation differing from that of centre.

Craspedodiscus coscinodiscus, (Ehr.) Marine.

Border broad, about the third of the entire diameter, areolate areoles hexagonal. Middle portion punctate. (Pl. 26, fig. 26.)

Ralfs, in Pritch., p. 832, Pl. v., fig. 80.—Craspedodiscus pyxidicula, Brightwell, Q. J. M. S., 1860, p. 95, Pl. v., fig. 4.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Genus IX. Actinoptychus, Ehr.

Disk undulate, divided into strongly defined somewhat triangular compartments, with a distinct polygonal centre, the sides of the polygon being equal to the number of compartments into which the disk is divided.

The valves in this genus appear to consist of two distinct plates, with a striation somewhat different, hence the species have by some being unnecessarily multiplied.

Actinoptychus senarius, (Ehr.) Brackish or marine.

Valve divided into six compartments, areolate, areolæ more or less hexagonal. In this species the valves vary considerably in size.

Ehr. Mic., T. xxi., fig. 18, a. b. Kütz. Bac., p. 134, T. i., fig. 21, T. xxi., fig. 26. The form there described does not differ from that which the same author has described and figured as Actinocyclus undulatus, Bac., p. 132, T. i., fig. 24. Ralfs, in Pritch., p. 839, Pl. ix., fig. 132.—Actinoptychus undulatus, Rab. Fl. Eur., sect. 1, p. 35.—Actinocyclus undulatus, Wm. Sm., B. D., Vol. i., p. 25; Plate v., fig. 43. Heib. De Danske Diat., p. 37. Cleve, Om Svenska och Norska Diat., p. 218.

Salt ditch near Wexford. Bannow, Co. Wexford. Rostrevor, Co. Down. Stomachs of Pectens, Dalkey. Dollymount. Portmarnock, Co. Dublin. Sea shore, near Ballysodare, Co. Sligo.

Var. denarius, (Ehr.) Marine.

Compartments ten in number. Ehr. Mic., T. xviii., fig. 23.

From stomachs of Ascidians, Roundstone Bay. Arran Islands, Westport Bay, Co. Galway.

Var. duodenarius, (Ehr.) Marine.

Compartments twelve in number. Ehr. Mic., T. xviii. f. 24. Ralfs, in Pritch., p. 840. Weisse, Bulletin de L'Academie Imp. de St. Petersbourg, Tome xii., p. 122, T. i., fig. 8.—Actinocyclus duodenarius, Wm. Sm., B. D., Vol. ii., p. 86.

From stomachs of Ascidians, Roundstone Bay. Arran Islands, Co. Galway.

Var. sedenarius, (Ehr.) Marine.

Compartments sixteen in number. Ehr. Mic., T. xviii., fig. 26. Weisse, Bulletin de L'Academie Imp. de St. Petersbourg, Tome xii., p. 122. T. i., fig. 9.—Actinocyclus sedenarius, Wm. Sm., B. D., Vol. ii., p. 86.

Sea-weeds, Bannow, Co. Wexford. Arran Islands. From stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. vicenarius, (Ehr.) Marine.

Compartments twenty in number. The only specimen of this variety found by me has marginal teeth obvious on some of the compartments, though not noticeable on others, owing perhaps to the circumstance of the valve not lying quite parallel to the side. These teeth disappeared altogether when the form was mounted in balsam. Ralfs, in Pritch., p. 840. Weisse, Bulletin de L'Academie Imp. de St. Petersbourg, Tome xii., p. 122.

Drehidnamaud, Co. Kerry.

Genus X. Omphalopelta, Ehr.

Valves as in Actinoptychus, but having a marginal spine in each compartment.

Omphalopelta areolata, (Ehr.) Marine.

Valve having six compartments, areolate; submarginal spines small.

Ehr. Mic., T. xxxv., A. Ralfs, in Pritch., p. 841, Pl. viii., fig. 15.—Actinocyclus areolatus, Brightwell. Q. J. M. S., 1860, p. 93, Pl. v., fig. 1.

Arran Islands, Co. Galway.

Genus XI. Actinocyclus, Ehr.

"Disk minutely and densely punctated, or cellulose, generally divided by radiating single or double dotted lines, and having a small circular hyaline intramarginal pseudo-nodule." "The disk is not undulated." Ralfs. To this description may be added, that the species of this genus usually exhibit a border in which the striæ are unlike those of the remainder of the disk; the striæ also almost or altogether reach the centre.

Actinocyclus Ralfsii, (Wm. Sm.) Marine.

Valve highly irridescent under a low power. Striæ radiate, moniliform; puncta nearly of uniform size throughout, the dividing radii equidistant, nearly reaching the centre; the next lines of puncta considerably shorter than the radii; the next again still shorter, exhibiting numerous subulate blank spaces; border tolerably wide, minutely punctate; submarginal nodule large, round; no central nodule, but the central portion marked by a few scattered puncta; diameter about ·0042. (Pl. 27, fig. 1.)

Ralfs, in Pritch., p. 835, Pl. v., fig. 84.—Eupodiscus Ralfsii, Wm. Sm., B. D., Vol. ii., p. 86.

Lough Kay, Co. Kerry. Stomachs of Pectens, Dalkey Sound, Co. Dublin. Stomachs of Ascidians, Belfast Lough, Co. Antrim.

Actinocyclus moniliformis, (Ralfs.) Marine.

Striæ moniliform, principal rays about twelve in number, running radiately from centre to border; intermediate rays becoming gradually shorter and parallel, except near the border, where a few short ones meet them at an angle. About four puncta, closely approximated in the centre, present the appearance of a nodule; border narrow, punctate; pseudo-nodule small, marginal. Diameter about ·0034. (Pl. 27, fig. 2.)

I have had considerable difficulty in identifying this species; in some respects it agrees with the description of Eupodiscus sparsus, Greg., Q. J. M. S., 1856, p. 81, Pl. i., fig. 47. But as it more nearly resembles specimens frequently to be met with in the Richmond deposit, which Ralfs seems to have had in view when he named the species, I have adopted his specific designation.

Ralfs, in Pritch., p. 834.

Salt ditch near Wexford. Sea-weeds, Ballybrack, Co. Dublin.

Actinocyclus crassus, (Wm. Sm.) Marine.

Striæ moniliform; principal rays strongly marked when viewed by a low power; arrangement of puncta somewhat confused; border narrow, punctate, puncta decussate; submarginal nodule small; diameter ·0020.

Ralfs, in Pritch., p. 835.—Eupodiscus crassus, Wm. Sm., B. D., Vol. i., p. 24, Pl. iv., fig. 41.

Sea-weeds, Ballybrack. Stomachs of Pectens, Dalkey Sound, Malahide, Howth, Co. Dublin. Stomachs of Ascidians, Co. Clare.

Actinocyclus fulvus, (Wm. Sm.) Marine.

Striæ moniliform, close, subradiate; border broad; striation indistinct; submarginal nodule small. Diameter about ·0025.

Ralfs, in Pritch., p. 835.—Eupodiscus fulvus, Wm. Sm., B. D., Vol. i., p. 24, Pl: iv., fig. 40.

Stomachs of Pectens, Dalkey Sound, Co. Dublin. Stomachs of Ascidians, Roundstone Bay, Co Galway.

Genus XII. Eupodiscus, Ehr.

Valves having horn-like processes springing from the surface.

Eupodiscus argus, (Ehr.) Marine.

Disk large, areolate; areoles irregular, somewhat angular, radiately disposed; processes three or four, submarginal. Diameter from ·0065 to ·0120. (Pl. 27, fig. 3.)

Wm. Sm., B. D., Vol. i., p. 24, Pl. iv., fig. 39. Ralfs, in Pritch., p. 843, Pls. vi., fig: 2, and xi:, figs: 41, 42: Heiberg, De Danske Diat., p: 37: Rab. Fl. Eur., sect. i., p. 319.—Tripodiscus argus, Kütz. Bac., p. 136, T. i., fig. 6.

Dublin Bay.

Genus XIII. AULISCUS, Ehr.

Surface of the valve undulate, furnished with two large processes; striæ plumose, arranged in form of a quatrefoil.

Auliscus sculptus, (Wm. Sm.) Marine.
Striæ linear. (Pl. 27, fig. 4.)
Ralfs, in Pritch., p. 845, Pl. vi., fig. 3. Greville, Q. J. M. S., 1863, p. 43, Pl. ii., figs. 1–3. Heiberg, De Danske Diat., p. 37. Cleve, Om Svenska och Norska Diat., p. 218.—Eupodiscus sculptus, Wm. Sm., B. D., Vol. i., p. 25, Pl. iv., fig. 42.—Aulacodiscus sculptus, Brightwell, Q. J. M. S., 1860, p. 94, Pl. v., fig. 3.

Malahide. Piles of wooden bridge, Dollymount, Co. Dublin. River Slaney, at Killurin, Co. Wexford. Sea-weeds, near town of Wicklow. Westport, Co. Galway.

Genus XIV. ODONTODISCUS, Ehr.

Disk furnished with marginal teeth.

In this genus I have united Ehrenberg's two genera, Odontodiscus and Systephania, deeming the distinction between them not of sufficient importance to justify their separation. The distinction, as expressed by Ralfs, is simply this, that in Odontodiscus "the dots are radiate, not parallel, as in Systephania."

Odontodiscus excentricus, (Ehr.) Marine.
Disk varying in size from ·0008 to ·0025; areolate; areoles round, arranged in curved excentric lines; teeth numerous, short. (Pl. 27, fig. 5.)
Ehr. Mic., T. xxxv., A. 18; fig. 11. Ralfs, in Pritch., p. 832. Pl. v., fig. 90.—Coscinodiscus excentricus, Kütz. Bac., p. 131, T. i., fig. 9, in which the teeth are not figured or described. Wm. Sm., B. D., Vol. i., p. 23, Pl. iii., fig. 38.—Eupodiscus excentricus, O'M., Q. J. M. S., 1867, p. 249, Pl. vii., fig. 2.

Sea-weeds, Bannow. Salt ditch near Wexford. Piles of wooden bridge, Dollymount, Malahide, Stomachs of Pectens, Dalkey, from Corallines, Howth, Sea-weeds, Ballybrack, Co. Dublin. Sea-weeds, Kilkee, Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Odontodiscus anglicus, (Donkin.) Marine.
Disk about ·0016 in diameter; teeth large and prominent, occupying a tolerably broad unstriate margin; striæ minutely punctate, decussately arranged. (Pl. 27, fig. 6).

Systephania anglica, Donkin, Q. J. M. S., 1861, p. 12, Pl. i., fig. 14.

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Odontodiscus hibernicus. N. S. Marine.

Disk about ·0018 in diameter; areolate; areoles round, decussately arranged, reaching the circumference; teeth more numerous than in former species, and shorter. (Pl. 27, fig. 7.)

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

A. *Frustules symmetrical. Valves not circular.*

FAMILY II. BIDDULPHIEÆ, Kütz.

Valves lanceolate, in some cases nearly orbicular, furnished with distinct processes and spines; connecting zone largely developed in full-grown specimens. In such species as have been seen in a living state the frustules are united in filaments.

This group, established by Kützing without any very distinct definition, embraced the following genera, Isthmia, Odontella, Biddulphia, and Zygoceros. Ralfs, in Pritchard, adopts the same system of grouping, adding to those above named two other genera, Hemiaulus, and Hydrosera, but gives more distinct characteristics than the former author. His diagnosis rests mainly on the convexity of the frustules, in consequence of which the lateral valves "enter largely into the front view," and on the development of processes on the valves. Grunow adopts the group with no more distinct definition than the following. "Side view longish, or having three, four, or more angles," and includes in it four genera, namely, Isthmia, Biddulphia, Amphitetras, and Triceratium. Heiberg marks the group by the fact of the processes springing from the valve obliquely outwards, and places under it the genera Cerataulus, Biddulphia, Triceratium, Amphitetras; and in a sub-group named Biddulphieæ cuneatæ, the genus Eucampia also. Immediately connected with the Biddulphieæ, this Danish author places another group, the Hemiaulidæ, mainly distinguished from the former by this one feature, that the processes, instead of springing from the valve obliquely, are placed at right angles with the plane of the base.

The genus Isthmia which Kützing, Ralfs, and Grunow include in the Biddulphieæ, differs considerably in these respects, that the frustules on the front view are not symmetrical, and the valves are not furnished with processes, the structure which Ralfs regarded as such being only a mucous cushion or stipes, and on these grounds the genus Isthmia ought to be excluded. In the case of Hydrosera (Wallich), the frustules are not symmetrical, processes occurring on the one valve, and not on the opposite one. Wallich's description is "on one side only, with a remarkable series of aperture-like appendages." Wallich on Triceratium, Q. J. M. S., July, 1858, p. 251. For which reason I consider the genus Hydrosera is not properly comprehended in the group. The species marked by an angular outline of the valves as Triceratium, Amphitetras, &c., however closely related to the Biddulphieæ, seem however to possess such distinctive peculiarities of structure as to justify their being placed in a separate group; and if any forms of the genus Hemiaulus had occurred in Irish localities, I would have been disposed to include them with the Biddulphieæ as Rabenhorst has done in his Flora Europea Algarum.

Various generic names have from time to time been introduced by different writers to designate the forms of this group, in consequence of which much confusion has arisen, to obviate which a few remarks are here necessary.

The generic name Biddulphia was first adopted by Gray, and along with Biddulphia pulchella embraced some heterogeneous forms, which latter were afterwards removed to their proper places. Agardh then established the genus Odontella to receive the single species now known as Biddulphia aurita; Ehrenberg having applied the name Odontella to a species of Desmid, as Roper informs us, Q. J. M. S., Oct., 1858, p. 3, substituted for it the designation Denticella, which was thus equivalent to Agardh's Odontella. The forms included in these genera, Biddulphia and Denticella, were filamentous; and Ehrenberg having found kindred forms which, without sufficient examination, he considered to be simple, adopted the genera Zygoceros and Cerataulus, the former for those free forms, as he thought them allied to Biddulphia, the latter to Denticella. Some of these genera have been retained by succeeding writers, but Smith in his Synopsis has, as I think, wisely dispensed with these superfluous subdivisions, and included the forms contained in them under the one generic name.

Rabenhorst, in his Flora Europea Algarum, places the Biddulphieæ in close connexion with the septate forms, supposing, as I imagine, that the costæ on the valves of Bid. pulchella and other species with undulate surfaces are septa. On this subject the observations of Smith are worthy of notice: "The existence of septa in B. pulchella is by no means to be admitted, though the costæ may occasionally project into the interior of the cells." B. D., Vol. ii., p. 49.

Genus I. Biddulphia, Gray.

Processes projecting outwards at a more or less acute angle from the plane of the base.

(a.) *Surfaces of the valves not undulate.*

Biddulphia radiata, (Wm. Sm.) Marine.

Valve nearly circular; cellules distinct, roundish, radiate, larger at the margin than towards the centre, where they are small and more distant; processes two, large, alternating with two others smaller and spine-like.

It is with some difficulty that I have come to the conclusion that this form is identical with that described by Wm. Smith, first as Eupodiscus radiatus, B.D., Vol. i., p. 24, Pl. xxx., fig. 255; and subsequently as Biddulphia radiata, Vol. ii., p. 48, Pl. lxii., fig. 255. Neither as regards the outline of the valve, nor its areolation, can this form be regarded as obviously the same as that described in Smith's figure, which is perfectly orbicular, whereas in the present case the outline, though nearly circular, presents four distinct angles, the processes being placed at opposite ends of one diagonal line, the spines occupying the corresponding position on the other. Roper, Q.J.M.S., Oct., 1858, p. 19, Pl. ii., fig. 29, and Ralfs, in Pritch., p. 847, affirm the orbicular outline of the valve; but Smith, who was subsequently convinced that the form was wrongly placed in the genus Eupodiscus, and that its proper position was in Biddulphia, uses such language as to imply that the outline is not perfectly circular. Marking the distinctive peculiarities of Eupodiscus and Biddulphia, he says, the frustules of the former differ from those of the latter, "by the orbicular outline of their valves." B.D., Vol. ii., p. 48. The present form differs from Smith's figure not only in the outline, but in the character and arrangement of the cellules. In the latter, the cellules are minute, close, and not radiately disposed, and on this point Ralfs alleges, "the cellules are not radiant," Pritch., p. 847. The specific name given to the species by Smith is, however, suggestive of the thought that the figure is at fault in this respect. Roper's figure of the species exhibits the cellules as small and radiately arranged, but in his description he represents them just as they are in the form under consideration, "as distinctly reticulated, with small but rather irregular hexagons."

Cerataulus Smithii, Ralfs, in Pritchard, p. 847. Cleve, Om Svenska och Norska Diat., p. 218. Rab. Fl. Eur., sect. i., p. 313.

Salt marsh near Ballysodare, Co. Sligo.

Biddulphia turgida, (Ehr.) Marine.

Connecting zone transverse; valves nearly orbicular, having two large truncate processes, and two alternate spines both situated diagonally; a circlet of small marginal spines sometimes present, and numerous minute spines scattered irregularly over the surface; striation minutely punctate, the puncta arranged in close wavy lines.

This, as well as the former species, are by Ralfs, Heiberg, Rabenhorst, and Cleve, placed in a distinct genus named Cerataulus, the distinctive characteristic being the fact that the processes and spines are diagonally situated on the valve.

Wm. Sm., B. D., Vol. ii., p. 50, Pl. lxii., fig. 384. Roper, Q. J. M. S., Oct., 1858, p. 17, Pl. ii., fig. 23. Ralfs, in Pritch, p. 846, Pl. vi., fig. 8. Heiberg, De Danske Diat, p. 39. Rab. Fl. Eur., sect. 1, p. 313.

Salt marsh, Ballysodare, Co. Sligo. Sea-weeds, Malahide, Co. Dublin.

Biddulphia aurita, (Lyngbye.) Marine.

Valves elliptical lanceolate, with the processes at the extremities of the longitudinal axis; processes large at the base, rounded off towards the fine extremity; the elevated centre of the valves bearing three fine and long spines; striation punctate, fine; puncta observed from front view, parallel; connecting zone finely punctate. (Pl. 27, fig. 8*a*).

Smith and Roper attribute this species to De Brèbisson; but with Ralfs, Heiberg, and Rabenhorst, I consider it should be ascribed to Lyngbye, who first described it as Diatoma auritum.

Wm. Sm., B. D., Vol. ii., p. 49, Pl. xlv., fig. 319. Roper, Q. J. M. S., Oct., 1858, p. 10, Pl. i., fig. 3. Ralfs, in Pritch., p. 849. Heiberg, De Danske Diat., p. 41. Rab. Fl. Eur., sect. 1, p. 311. Cleve, Om Svenska och Norska Diat., p. 218.—Denticella aurita, Ehr. Mic., T. xxxv., A 23, fig. 7.—Odontella aurita, Kütz. Bac., p. 137, T. xxix., fig. 88.

Stomachs of Ascidians, Roundstone Bay, Co. Galway. Sea-weeds, Ballybrack, Malahide, Dollymount, Howth, Co. Dublin. Rostrevor, Co. Down. Tacumshane, Co. Wexford. Laytown, Co. Meath. Ballysodare, Co. Sligo. Dundalk, Co. Louth.

Biddulphia rhombus, (Ehr.) Marine.

Valves orbicular-lanceolate; processes at the extremity of the longitudinal axis; spines marginal; central elevation slight; striation finely punctate, seen on front view, parallel; connecting zone finely punctate.

Ehrenberg described this form as Zygoceros rhombus; to him, therefore, should it be ascribed, and not to Wm. Smith, as some authors have done.

Wm. Sm., B. D., Vol. ii., p. 49, Pl. lxi., fig. 320. Roper, Q. J. M. S., Oct., 1858, p. 11, Pl. i., fig. 4. Heiberg, De Danske Diat., p. 40. Rab., Fl. Eur., sect. 1, p. 311. Cleve, Om Svenska och Norska Diat., p. 218.—Zygoceros rhombus, Ehr., Berl. Acad., 1839, p. 156. Kütz. Bac., p. 138. T. xviii., fig. 9. Ralfs, in Pritch, p. 850.

Malahide, Baldoyle, Ballybrack, Dollymount, Co. Dublin.

Biddulphia baileyii, (Wm. Sm.) Marine.

Frustules, on front view, receding at the sides in a gentle slope; end surfaces nearly flat, with two slight elevations on which the spines are situated; processes long, and narrow towards the extremity, slightly curving inwards; striation very obscure; punctate; puncta parallel. On side view valves broadly elliptical; processes at extremities of the longitudinal axis; spines two, situated a little to the right and left of same, about one-third of the entire length from extremities; striæ very fine; lines of puncta appearing to cross each other, except upon a vacant, sigmoid, narrow space in the middle. (Pl. 27, fig. 8.)

Wm. Sm., B. D., Vol. ii., p. 50, Pls. xlv. and lxii., fig. 322. Rab. Fl. Eur., sect. 1, p. 311. Roper, Q. J. M. S., Oct., 1858, p. 12, Pl. i., figs. 5–9.—Zygoceros mobiliensis, Ralfs, in Pritch, p. 850, Pl. vi., fig. 11.

Salt ditch near Wexford. Tacumshane, Co. Wexford. Dundalk, Co. Louth. Salt marsh, Drehidnamaud, Co. Kerry.

(b.) *Surfaces of the valves undulate.*

Biddulphia pulchella, (Gray.) Marine.

On front view the sides incline inwards towards the processes; the valves divided into compartments, from three to seven in number, the central being the largest and most elevated, from which, in perfect specimens, two or three spines are projected; compartments separated by what appear strong costæ; processes short, rounded at extremities; striation areolate; areoles roundish, and nearly parallel; connecting zone striate. On side view the valve is broadly elliptical; areoles ranged round the central point. (Pl. 27, fig. 9.)

Wm. Sm., B. D., Vol. ii., p. 48, Pls. xliv., xlv., xlvi., fig. 321. Roper, Q. J. M. S., Oct., 1858, p. 7. Ralfs, in Pritch, p. 848, Pl. ii., figs. 46–50.—Biddulphia trilocularis; B. quinquelocularis; B. septemlocularis, Kütz. Bac., p. 138, T. xxix., fig. 89, T. xix., fig. 1, T. xix., fig. 2.—Diatoma Biddulphianum, Agardh, Syst. Alg., p. 5.—Denticella Biddulphia, Ehr., Berl. Trans., 1843.

Malahide, Ireland's Eye, Baldoyle, Co. Dublin. Sea-weeds, Giants' Causeway, Co. Antrim. Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway.

Family III. TRICERATIEÆ.

Valves on side view presenting three or more angles, with a process springing from each angle.

This group includes the genera Amphitetras, Triceratium and Trinacria, which, in consequence of their obvious resemblance, are placed here, although differently arranged by other authors. Wm. Smith, recognising the affinity between Biddulphia and Amphitetras, placed them close together, but assigned to Triceratium a widely different position in his system of arrangement. Kützing distributes the included genera in two distinct groups—the Anguliferæ and Angulatæ, between which he interposed the Biddulphieæ and Tripodiscus argus = Eupodiscus argus. The Anguliferæ, he says, "are easily distinguished by means of their angular side view;" but of the Angulatæ, which embraces only the single genus Triceratium, he gives no other diagnosis than that contained in the description of that genus, "individuals free, with the bivalve lorica triangular, not concatenated," Ralfs omits Trinacria, a genus established by Heiberg subsequently to the publication of the "History of the Infusoria," and along with the other genera placed in the present group includes Euodia, and Hemidiscus. Of Hemidiscus I have never seen a specimen, and, therefore, can express no opinion regarding it; but as to Euodia, from the cuneate outline of its transverse section, it plainly should be excluded from this group, with which it has little, if any, affinity. Ralfs indicates two features by which the forms in this group may be distinguished from the Biddulphieæ: "The angles on the front view are usually less elongated, and the intervening margin less lobed." Of these characters the latter can scarcely be sustained in all cases; and as to the former, if Trinacria, in which the processes at the angles are very long, is to be admitted here, this, too, must be regarded as by no means a satisfactory diagnosis. Grunow does not refer to Trinacria, for the same reason as Ralfs, but includes the other forms of this group under the Biddulphieæ, which he thus defines: "Valves on side view longish, or three, four, or more angled," no reference being made to the processes springing from the angles which constitute so remarkable a feature of these forms. According to this author, the characteristic distinction between Amphitetras and Triceratium is the possession of four angles by the former, while the latter has but three. The fact that specimens of the former occur with five angles, and of the latter with four or more angles, evinces how untenable is this distinction as a generic diagnosis.

Heiberg includes Amphitetras and Triceratium in the Biddulphieæ, and his genus Trinacria in another group, namely, the Hemiaulidæ; the main distinction of which rests on the form and position of the processes, which are triangular, and spring at right angles from the basal plane of the valve. But these differences, though sufficient to establish generic distinction, seem scarcely to justify the establishment of a distinct group to receive the forms. It will thus appear that, in consequence of the projection of the processes from the angles of the valves, the relationship of this group to the Biddulphieæ is recognised by most authors: but no more satisfactory distinction between Amphitetras and Triceratium has been suggested than that in the former the frustules are concatenate, and in the other free. This distinction I adopt, not because I consider the supposed fact on which it rests in all cases substantiated by observation, but because it seems the most satisfactory. And not being in a position either to sustain or refute the assumption, I consider the proper course is to leave them as they stand.

Genus I. AMPHITETRAS, Ehr.

Frustules concatenate; cubical; processes springing from each angle of the valve short.

Amphitetras antediluviana, (Ehr.) Marine.

Striation areolate; connecting zone more finely areolate than the valve. On side view, margins deeply concave; areoles radiate and concentric. (Pl. 27, fig. 10.)

Kütz. Bac., p. 135, T. xix. fig. 3; T. xxix. fig. 86. Ralfs, in Pritch., p. 858. Heiberg, De Danske Diat., p. 42. Rab. Fl. Eur., sect. 1, p. 318.—Amphitetras antediluviana, *β*. W. Sm., B. D., Vol. ii. p. 47, Pl. lxiv., fig. 318 a'''.

Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway.

Variety a.—On side view, sides parallel.—Amphitetras antediluviana, Wm. S., B. D., Vol. ii., p. 47, Pl. xliv., fig. 318. Ralfs, in Pritch., p. 858, Pl. xi., figs. 21 and 22.

Stomachs of Ascidians, Roundstone Bay. Arran Islands, Co. Galway. Malahide. Dublin Bay. Howth, Co. Dublin. Bundoran, Co. Donegal.

Variety b.—With five angles.

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Genus II. TRICERATIUM, Ehr.

Frustules simple; normally triangular on side view; processes short, roundish, springing outwards, at an acute angle to the basal plane.

Triceratium favus, (Ehr.) Marine.

Striation areolate; areoles hexagonal, large; sides straight or slightly convex.

Kütz. Bac., p. 139, T. xvii., fig. 11. Wm. Sm., B. D., Vol. i., p. 26, Pl. v., fig. 44; Supp. Pl. xxx., fig. 44. Ralfs, in Pritch., p. 855. Pl. xi., fig. 43. Heiberg, De Danske Diat., p. 41. Rab. Fl. Eur., sect. 1, p. 315.

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Triceratium alternans, (Bailey.) Marine.
Sides nearly straight; striation areolate; areoles small, roundish; radiating towards the three angles; bases of the processes marked by what seem well defined costæ. (Pl. 27, fig. 11.)
Bailey, Mic. Observations made in Sth. Carolina, Smithsonian Contributions, Vol. ii., p. 40. Brightwell, Q. J. M. S., Vol. i., p. 251, Pl. vi., fig. 19. Wm. Sm., B. D., Vol. i., p. 26, Pl. v., fig. 45. Supp. Pl. xxx., fig. 45. Ralfs, in Pritch., p. 854, Pl. vi., fig. 21. Rab. Fl. Eur. sect. 1, p. 316.

Mud of River Liffey, Co. Dublin.

Triceratium amblyoceros, (Ehr.) Marine.
Sides convex; angles broadly rounded off; cellules radiate, distant, roundish; more deeply shaded at the borders. (Pl. 27, fig. 12.)
Ehr. Mic., T. xviii., fig. 51. Brightwell. Q. J. M. S., Vol. i., p. 250, Pl. iv., fig. 14. Ralfs, in Pritch., p. 857.

Stomachs of Poolbeg oysters. Dublin Bay.

Triceratium exiguum, (Wm. Sm.) Fresh water.
Valve very minute; areoles minute; angles elongated; sides inflexed. (Pl. 27, fig. 13.)
Wm. Sm., B. D., Vol. ii., p. 87. Brightwell, Q. J. M. S., 1856, p. 274, Pl. xvii., fig. 1. Ralfs, in Pritch., p. 857, Pl. vi., fig. 16.

River Liffey, Co. Dublin.

Genus III. Trinacria, Heiberg.

Frustules normally triangular; processes springing from the surface at a right angle, and surmounted by two curved spines; transverse section of the processes triangular.

Trinacria regina, (Heiberg.) Marine.
As but one specimen of this species has been met with by me, and that mounted in balsam, instead of giving my own diagnosis I consider it better to transcribe the exhaustive description of Heiberg.
"Outline of the basal-surface triangular, with an extended depression towards the centre and the short pointed angles. The outline of the side view less than that of the basal-surface, its sides bulged in the middle, and evenly depressed on both sides of the same. The side-surface separated from the front surface by a thick projecting border. The end-processes of varying height, with a prominent keel on the outer margin; spines slightly crescentic. The portion of the side-surface lying between the processes at the angles forms a gently elevated ridge, which again has a slight depression towards the middle

point. The striation of the valves formed of moderately scattered granules, arranged in curved radiating lines, slight or absent; about the middle point, more robust, and consisting of angular granules arranged in three or four longitudinal lines, and in short transverse lines diverging towards the suture, or that portion of the side-surface of the valve which lies between each pair of end-processes. Granules about 22 in 0.05^{mm} along the suture; striation of the connecting-zone unknown; length of the side of the basal surface = 0·055^{mm} – 0·175^{mm}." This beautiful form I considered to be an undescribed species of Triceratium, until I saw Heiberg's figure of Trinacria regina, when I at once recognised its identity. (Pl. 27, fig. 14).

Heiberg, De Danske Diat., p. 50, T. iii., fig. 7.

Arran Islands, Co. Galway.

In reference to the locality of this form, Heiberg says:—"It occurs abundantly in the brown Moleer from Fuur, in which it is one of the most common forms. In the white Moleer I have found only a few single specimens." It is then a matter of interest to discover it on our own coasts.

FAMILY IV. ISTHMIEÆ, Agardh.

Frustules trapezoidal on front view, on the side view broadly elliptical, without processes; one valve having the extreme corner produced, at the end of which is secreted the mucous cushion by which frustule is united to frustule, so as to form an irregularly branched filament.

In a classification founded on the symmetrical or unsymmetrical shape of the frustule, this family should in strictness be assigned to a different position; but I place it here not only in deference to the views of all authors known to me, but because in point of fact it presents considerable analogy to the Biddulphieæ, and without violence could not be suitably placed at a distance from that group.

Genus I. ISTHMIA, Agardh.

Characters of the Genus those of the Family.

Isthmia nervosa, (Kütz.) Marine.

Striation of valves areolate; areoles large, close, somewhat hexagonal, with numerous strong anastomosing costæ springing from the margin, and disappearing towards the middle of the valve; connecting membrane areolate, areoles much smaller than those on the valve (Pl. 27, fig. 15.)

Kütz. Bac., p. 137, T. xix., fig. 5. Wm. Sm., B. D., Vol. ii.,

p. 52, Pl. xlvii. Ralfs, in Pritch., p. 581. Rab. Fl. Eur., sect. 1, p. 309.

This and the following species have been described by different authors under different generic and specific names, *e. g.*, Isthmia obliquata, Ag.; Diatoma obliquatum, Lyng.; Isthmia obliquata tenuior, Ag.; Conferva obliquata, Engl. Bot., tab. 1869; but as it is not certain in all cases which of the two species was intended, it seems better not to attempt further identification.

Collected in great abundance by Dr. D. Moore on Polysiphonia in Camlough Bay, Co. Antrim; and found by me in almost every marine gathering from that place northwards, but not at all in the same profusion. Malahide, Co. Dublin.

Isthmia enervis, (Ehr.) Marine.

Striation of valves areolate, areoles quadrangular; without costæ; areoles on connecting membrane much smaller, and roundish.

The frustules are generally slighter than in the former species, but the distinctive characters are, first, the absence of the costæ, and secondly, the want of a distinct border on the valve in side view, so conspicuous in Isthmia nervosa.

Kütz. Bac., p. 137, T. xix., fig. 4. Wm. Sm., B. D., Vol. ii., p. 52, Pl. xlviii. Ralfs, in Pritch., p. 851, Pl. x., fig. 183. Rab. Fl. Eur., sect. 1, p. 309.

Stomachs of Ascidians, Roundstone Bay. Arran Islands, Co. Galway. Malahide, Co. Dublin.

Family V. FRAGILARIEÆ, Kütz.

Frustules in front view rectangular, without median line, central nodule, or internal diaphragms. The frustules are usually attached by a stipes, or united together in parallel or zig-zag filaments.

The group thus limited embraces the following genera:—Fragilaria, Denticula, Odontidium, Plagiogramma, Dimeregramma, Diatoma, Synedra, Raphoneis, and is tolerably well defined by the common characteristics above specified. In the case of Raphoneis indeed it is doubtful whether the frustules are free or stipitate. I have never seen them in a growing state, but in other respects they exhibit the common character of the Fragilarieæ.

The above genera have been distributed by different authors very differently from their present arrangement. Kützing grouped such of the above genera as were known to him under the Fragilarieæ, with the exception of Synedra, which he and others have unaccountably, as it appears to me, placed under the Surirelleæ. William Smith, who attaches great importance to what others have regarded as a subordinate feature—namely, the attachment of the frustules in filaments—has accordingly placed together such of the above-mentioned genera as seem to have been known to him, with the exception of Synedra, which he has ranged immediately after Pleurosigma. The position thus assigned to Synedra may possibly be owing to his supposing that the median, longitudinal, narrow, unstriated space, and the unstriated central space, which some of the forms present, are analogous to the median line and central nodule of the Naviculaceæ. Grunow has adopted a group, which he has named Diatomeæ, distributed into two sub-groups, distinguished by the absence of diaphragms in the one, and the presence of this structure in the other. The former very nearly corresponds with Fragilarieæ as here defined. The genera which Grunow includes in the first sub-group of Diatomeæ are Odontidium, Diatoma, Plagiogramma, Fragilaria, Dimeregramma, his new genus Cymatosira, Grammonema, Raphoneis, Doryphora, Synedra, Asterionella, and Desmogonium. Of these, Grammonema is considered by Ralfs, Kützing, Ehrenberg, and Meneghini, as not diatomaceous. If, however, it belong to the Diatomaceæ, as I think it does, its proper position is with the Fragilarieæ. Doryphora, Grunow describes as a stipitate Raphoneis, while in reality it is a stipitate Navicula, and should therefore be ranked with the Naviculaceæ. Asterionella should be excluded from this group, in consequence of its unsymmetrical outline, both on the front and side views; while the general characters of Desmogonium are those of the Fragilarieæ. Ralfs adopts Fragilarieæ as the designation of a group in which he includes Denticula, Plagiogramma, Odontidium, Fragilaria, Grammonema, Diatoma, all of which are placed by me in the present group; but he adds also the following very heterogeneous genera:—Asterionella, Nitzschia, Ceratoneis, and Amphipleura; while Synedra, Desmogonium, Dimeregramma, Staurosira, Raphoneis, under which he includes Doryphora, are ranged under the Surirelleæ. These latter genera seem to have little in common with the Surirelleæ, while, with the exception of Doryphora, already referred to, they exhibit the general features of the Fragilarieæ; Asterionella, Nitzschia, and Ceratoneis, which is unnecessarily separated from Nitzschia, on account of having unsymmetrical frustules, are incongruously forced into this group; and Amphipleura, by its conspicuous median line, is more analogous to the Naviculaceæ. Lastly, Heiberg adopts Kützing's group of Fragilarieæ, which he divides into two sub-groups—Fragilarieæ genuinæ, and Fragilarieæ cuneatæ. The former, so far as it extends, corresponds with the present group, while the genera contained in the latter, Meridion and Asterionella, seem so incongruous that they should be placed in a widely different position.

Genus I. FRAGILARIA, Lyngb.

Frustules on front view more or less perfectly quadrangular, united in filaments, in which they are parallel; connecting zone usually very narrow; striæ on the side view very fine, usually persistent, and appearing on the front view, where they form a narrow margin.

Fragilaria capucina, (Desmazieres.) Fresh water.

Frustules flat, so that the band of striæ appearing on the front view is very narrow. On side view the valves are narrow, linear, with either acute or slightly rounded apices; striæ very fine, persistent.

This species includes Fragilaria acuta, which is scarcely distinguishable from it.

Kütz. Bac., p. 45, T. xvi., fig. 3. Rab. Süssw. Diat., p. 33; T. i., fig. 2. Wm. Sm., B.D., Vol. ii, p. 22, Pl. xxxv., fig. 296. Ralfs, in Pritch., p. 776. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 372. Castracane, Catalogo di Diat. raccolte nella Val. Intrasca, p. 15.

This species is of almost universal occurrence.

Fragilaria virescens, (Ralfs.) Fresh water.

Frustules more arched than in the preceding species, and the marginal line of striæ, as seen on the front view, therefore wider. On side view linear, or slightly elliptical; narrowed at the ends, but not constricted; striæ fine, persistent.

Ralfs, A. N. H., Vol. xii., Pl. ii., fig. 6. Kütz. Bac., p. 46, T. xvi., fig. 4. Rab. Süssw. Diat., p. 33, T. i., fig. 1. Wm. Sm. B. D., Vol. ii, p. 22, Pl. xxxv., fig. 297. Ralfs, in Pritch., p. 777. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 373, T. iv., fig. 15. Heiberg, De Danske Diat., p. 60. Castracane, Catalogo di Diat. raccolte nella Val. Intrasca, p. 15. Cleve, Om Svenska och Norska Diat., p. 219.

Friarstown, Piperstown, Killikee, Co. Dublin. Glenchree, Greenane, Co. Wicklow. Feighcullen, Co. Kildare. (Moanarone, Co. Cork; Wm. Sm.)

Fragilaria æqualis, (Heiberg.) Fresh or Brackish water.

Frustules considerably longer than in the last species; on side view linear; ends attenuated and rounded; striæ fine, persistent. Heiberg's figure represents the striæ as interrupted by a narrow median space, but in the forms that came under my inspection the striæ, although at first they seemed interrupted, as described by Heiberg, on closer examination were obviously persistent.

Heiberg, De Danske Diat., p. 61, T. iv., fig. 12. Cleve, Om Svenska och Norska Diat., p. 219.

Oyster beds, Malahide, Co. Dublin.

Fragilaria maxima, N. S. Fresh water.

Frustules very large; on side view, considerably expanded in the middle, and gradually tapering towards the rounded ends; striæ fine, persistent. (Pl. 27, fig. 16.)

Aghold, Co. Wicklow.

Fragilaria crotonensis, (Kitton.) Fresh water.

Frustules long; margins on front view slightly waved; on the side view narrow; very slightly expanded in the middle, and gently attenuated towards the slightly capitate ends; striæ fine, persistent.

This species seems widely diffused, having been found by me in gatherings made by Mr. Mozeley, of H.M.S. Challenger, at Kerguelin's Land.

Pond, Newcastle Lyons, Co. Dublin. Mill-pond, Greenane, near Rathdrum, Co. Wicklow. Lough Derg, Co. Galway. Bundoran, Co. Donegal.

Fragilaria tenuicollis, (Heib.) Fresh water.

Frustules small; on front view slightly attenuated at the ends; on side view narrow, considerably expanded in the middle, and gently attenuated towards the capitate, rounded ends; striæ fine, persistent.

Heiberg, De Danske Diat., p. 62, T. v., fig. 13.

Mill-pond, Greenane, near Rathdrum, Co. Wicklow. Malahide, Co. Dublin.

Fragilaria striatula, (Lyngb.) Marine.

Frustules short; on side view linear, rounded at the ends; striæ extremely fine, persistent.

Lyngbye, Tent. Hydr. Dan., p. 183, T. lxiii. Wm. Sm., B. D., Vol. ii., p. 23. Cleve, Om Svenska och Norska Diat., p. 219.—Fragilaria aurea, Grev. Brit. Flora, p. 403. Harvey's Manual, p. 197.—Grammonema jurgensii, Agardh, Consp., p. 63. Ralfs, in Pritch., p. 778, Pl. xv., figs. 24, 25. Rab., Fl. Eur., sect. 1, p. 124.—Grammatonema stratulum, Kütz. Sp. Alg., p. 187.

Salt ditch, Arklow, Co. Wicklow. Ballybrack, Monkstown, Kingstown, Co. Dublin. Larne, Rathlin Island, Co. Antrim.

Fragilaria construens, (Ehr.) Fresh water.

Frustules short; on side view greatly expanded; ends short and attenuated; striæ fine, persistent.

Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 371. Rab., Fl. Eur., sect. 1, p. 120.—Staurosira construens, Ehr. Mic., T. iii. 3, fig. 8; T. iii. 1, fig. 15; T. xxxix. 2, fig. 10. Ralfs, in Pritch., p. 791. Pl. xv., fig. 5.—Odontidium tabellaria, Wm. Sm.,

B. D., Vol. ii., p. 17. Pl. xxxiv., fig. 291 *a.*, and Fragilaria undata, Supp. Pl. lx., fig. 377 *a.*

Piperstown, Killikee, Co. Dublin. Verner's Bridge, Co. Armagh, Float bog, Co. Westmeath.

Wm. Smith has described a form as Odontidium parasiticum, sometimes expanded in the middle, sometimes constricted, B. D., Vol. ii., p. 19, Supp. Pl. lx., fig. 375. The separate valves of the latter would seem to be a variety of the following species, those of the former to belong to the present; the habit of growth, however, is much more that of Synedra than of Fragilaria. Some few specimens have occasionally come under my notice, parasitic on Nitzschia sigmoidea, and in no way differing from the representation in Smith's figure. So seldom, however, did they occur, and in such small quantity, I never could make any satisfactory examination of them, and therefore refer to the subject here in deference to the opinions of the best authors, who have placed them in the genus Fragilaria—not because I agree with them in considering such is their proper place, but because I consider it inexpedient to make any change until an opportunity for more thorough examination shall have been afforded.

The forms have occurred in gatherings from Bohernabreena and Killikee, Co. Dublin.

Fragilaria undata, (Wm. Sm.) Fresh water.

Valves broad on side view; constricted in the middle; ends attenuated; striæ strong, persistent.

Wm. Sm., B. D., Vol. ii., p. 24, Supp. Pl. lx., fig. 377.—Odontidium tabellaria, Wm. Sm., B. D., Vol. ii., p. 17; Pl. xxxiv., fig. 291 *a.*—Fragilaria constricta in part, Ralfs, in Pritch., p. 777.—Fragilaria virescens var. undata, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 374. Grunow regards this form as likely identical with Fragilaria constricta, Ehr. Mic., T. xvi., 2, figs. 34, 35; as also with F. binodis, Ehr. Mic., T. vi. 1, fig. 43; but as there is some doubt on this point, and as some of the figures of the forms so named appear to be incorrectly attributed to this species, it is better to refer the species to Wm. Smith, whose figure admits of no doubt.

Bohernabreena, Killikee, Co. Dublin.

Fragilaria mesolepta, (Rab.) Fresh or brackish water.

Frustules on front view regularly quadrangular; on side view narrow, constricted at the middle, and more slightly constricted towards the apices, which are narrowed, produced, and sub-capitate; striæ fine, persistent.

Heiberg, De Danske Diat., p. 61, T. iv., fig. 11.—Fragilaria capucina var. mesolepta, Rab., Fl. Eur., sect. 1, p. 118.

Rock pool on sea-shore, Carrickfergus, Co. Antrim. Malahide; Basin, Ringsend, Co. Dublin.

Genus II. DENTICULA, Kütz.

Frustules united in parallel filaments; on front view regularly quadrangular, on side view narrow, elliptical, costate, costæ not pervious.

Kützing's distinction between this genus and Odontidium is not very obvious. Smith entertains considerable doubt as to the propriety of separating them, but distinguishes them by the relative length of the filaments. Those whose frustules form short filaments, he attributes to Denticula, while those forming filaments of considerable length constitute the genus Odontidium. Ralfs retains the two genera, interposing that of Plagiogramma between them, and remarks that, in the valves of Denticula, fine striæ are interposed between the costæ, this peculiarity not being noticeable in the valves of the several species of Odontidium. Rabenhorst also retains the two genera, and interposes the genus Gomphogramma between them, his distinguishing character being the same as that on which Smith relies. Grunow relegates the genus Denticula to the group Nitzschieæ, separating from it Denticula obtusa, Kütz., which he includes under Fragilarieæ; while Heiberg, who appears to be followed by Cleve, drops both genera, referring Odontidium parasiticum, Wm. Sm., to the genus Fragilaria, and Odontidium mutabile, Wm. Sm., to the genus Diatoma.

The distinctive characters of the genera, as here defined, rest on the fact that, in Denticula, the costæ are interrupted by a broader or narrower intermediate space, while the costæ in Odontidium are pervious.

Denticula obtusa, (Kütz.) Fresh water.

Filaments short; on side view narrow; elliptical, costæ marginal, with fine pervious striæ interposed.

Kütz. Bac., p. 44, T. xvii., fig. 14. Rab. Süssw. Diat., p. 33, T. i., fig. 8. Wm. Sm., B. D., Vol. ii., p. 19, Pl. xxxiv., fig. 292. Ralfs, in Pritch., p. 773.

River Dodder, Basin of Grand Canal, Co. Dublin.

Denticula mutabilis, (Wm. Sm.) Fresh water.

Frustules varying greatly in size, generally forming long filaments; on side view nearly oval, and sometimes narrow, elliptical; costæ broadly marginal, without interstitial striæ. (Pl. 27, fig. 17.)

Odontidium mutabile, Wm. Sm., B. D., Vol. ii., p. 17, Pl. xxxiv., fig. 290. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 369.—Fragilaria mutabilis, Rab. Fl. Eur., sect. 1, p. 118. Diatoma mutabile, Heiberg, De Danske Diat., p. 58. Cleve, Om Svenska och Norska Diat., p. 219.—Dimeregramma mutabile, Ralfs, in Pritch., p. 790.

Smith, with doubtfulness, refers Diatoma tenue, Kütz. Bac., p. 48, T. xviii., figs. 9, 10, and Odontidium striolatum, Kütz. Bac., p. 45, T. xxi., fig. 20, to this species; and Grunow, under Diatoma tenue, Kütz., remarks, "I do not find this variety described in Wm. Smith's Brit. Diat.," Verhand der K. K. Zool. Bot., Gesel., Band xii., 1862, p. 362. As so much doubt rests upon the forms described by Kützing, I have referred the species to Wm. Sm., whose accurate figure removes all doubt as to the identification of it.

Lough Mourne deposit. Ditch near Giants' Causeway, Ballyleg, Co. Antrim. Derrylane Lough, Stream near Crossdoney, Co. Cavan. Lucan, Bohernabreena, Co. Dublin. Connemara, Co. Galway. Black Castle, Glenchree, Co. Wicklow. Feighcullen, Royal Canal, near Enfield, Co. Kildare. Tacumshane, Co. Wexford. Killeshin, Queen's County.

Genus III. Odontidium, Kütz.

Frustules united in longer or shorter parallel filaments; on front view regularly rectangular, on side view elliptical, costate; costæ pervious; their ends very conspicuous on front view.

Odontidium sinuatum, (Wm. Sm.) Fresh water.

Frustules united in short filaments; on side view somewhat lanceolate; outline sinuous; expanded and angular in the middle; costæ relatively fine.

In consequence of the supposed excentric structure of the frustule of this species, Grunow has transferred the genus Denticula, as before stated, to the group Nitzschieæ; and Rabenhorst, taking the same view of the structure of the frustule, adopts his suggestion, but establishes a special genus, Grunowia, for its reception, a course in which he is followed by Cleve. This treatment appears to me inadmissible, inasmuch as the frustules are, in general structure, perfectly symmetrical. In some specimens the striation appears on one side, while the opposite side seems destitute of costæ. This may be an illusory appearance, arising from the convexity of the valve when viewed at an angle to the plane of the field; but, certainly, it is by no means universal. By accurate adjustment I have traced the costæ from one side to the other, and at the extremities, where the convexity appears less than in the middle, the persistent character of the costæ is easily traced.

Denticula sinuata, Wm. Sm., B. D., Vol. ii., p. 21, Pl. xxxiv., fig. 295. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 14. —Dimeregramma sinuatum, Ralfs, in Pritch., p. 730, Pl. iv., fig. 12.

River Dodder, Co. Dublin. Slate quarry, Glanmore, Co. Wicklow. Lough Gill, Co. Kerry.

Odontidium hyemale, (Lyngb.) Fresh water.

Frustules in long filaments; valve on side view narrow, elliptical; costæ strong, about ten in number, with distinct linear striæ between the costæ; ends of costæ on front view forming a narrow margin.

Kütz. Bac., p. 44, T. xviii., fig. 4. Rab. Süssw. Diat., p. 34, T. ii., fig. 4. Wm. Sm., B. D., Vol. ii., p. 15, Pl. xxxiv., fig. 289. Ralfs, in Pritch., p. 775, Pl. xiii., fig. 25. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 356.—Diatoma hyemale, Heiberg, De Danske Diat., p. 58. Cleve, Om Svenska och Norska Diat., p. 219. —Fragilaria hyemalis, Lyngb., Tent. Hydr. Dan., p. 63.

Wet rock, Black Castle, Co. Wicklow. Streamlet near Belfast, Co. Antrim.

Odontidium mesodon, (Ehr.) Fresh water.

Frustules united in long filaments, shorter, wider, and broader than in the preceding species; on side view broadly elliptical, with three to five strongly developed costæ, which, in consequence of the greater convexity of the valve, appear longer on the front than in the foregoing species; fine striæ may be discovered between the costæ without much difficulty. (Pl. 27, fig. 18.)

Heiberg attributes the species to Lyngbye, Smith to Kützing; but as Kützing himself identifies it with Fragilaria mesodon of Ehr, and the Fragilaria hyemalis of Lyngbye is regarded by the same writer as identical with both Odontidium hyemale and O. mesodon, the species may properly be referred to Ehrenberg.

Kütz. Bac., p. 44, T. xvii., fig. 1. Rab. Süssw. Diat., p. 34, T. ii., fig. 2. Wm. Sm., B.D., Vol. ii., p. 16, Pl. xxxiv., fig. 288. Ralfs, in Pritch., p. 75.—Odontidium hyemale var. mesodon, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 357.—Fragilaria mesodon, Ehr. Mic., T. ii., fig. 9.—Diatoma hyemale, Heib., De Danske Diat., p. 58. Cleve, Om Svenska och Norska Diat., p. 219. Both these last named authors regard this and the preceding species merely as varieties.

Friarstown, Piperstown, Co. Dublin. Glenchree, Powerscourt, Co. Wicklow. Well at Farraghy, River Dour, Co. Cork.

Odontidium anomalum, (Wm. Sm.) Fresh water.

Filaments short; frustules on front view usually exhibiting internal cells, likely the result of imperfect self-division; on side view narrow, linear, slightly constricted at the ends. Costæ strong, about eight or ten in number.

Wm. Sm., B.D., Vol. ii., p. 16, Supp. Pl. lxi., fig. 376. Ralfs, in Pritch., p. 776. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 357, T. iv., fig. 4. Rab. Fl. Eur., sect. 1, p. 116.

Ditch near Newcastle, Co. Wicklow. This form is usually found in Alpine districts.

Odontidium tenue, (Kütz.) Fresh water.

Frustules united in short filaments; on side view narrow, elliptical, with sharp ends; costæ numerous, with interrupted linear striæ interposed.

Denticula tenuis, Kütz. Bac., p. 43, T. xvii., fig. 8. Wm. Sm., B.D., Vol. ii., p. 20, Pl. xxxiv., fig. 293. Ralfs, in Pritch., p. 773. Rab. Fl. Eur., sect. 1, p. 114.

Powerscourt, Co. Wicklow. River Dour, Co. Cork.

Odontidium inflatum, (Wm. Sm.) Fresh water.

Frustules united in short filaments; on side view short, broadly elliptical, costæ close.

Denticula inflata, Wm. Sm., B. D., Vol. ii., p. 20, Pl. xxxiv., fig. 294. According to Ralfs, = Denticula crassula, Nägeli. Ralfs, in Pritch., p. 773. Rab. Fl. Eur., sect. 1, p. 115.

River Dour, Co. Cork.

Odontidium elegans, (Kutz.) Fresh water.

Frustules united in short filaments, on front view slightly elliptical; truncate, with large glandular expansions at the ends of the costæ; on side view, narrow, elliptical, pointed at the ends; costæ close.

Denticula elegans, Kütz., p. 44, T. xvii., fig. 5. Rab. Süssw. Diat., p. 33, T. i., fig. 4. Ralfs, in Pritch., p. 773, Pl. xiii., fig. 4. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 549. Rab. Fl. Eur., sect. 1, p. 115.—Denticula ocellata, Wm. Sm., B. D., Vol. ii., p. 20.

Rocks, Bundoran, Co. Donegal. Powerscourt, Rathdrum, Co. Wicklow. Rocks near the sea at Black Castle, and the Silver sands in the neighbourhood of Wicklow. Rocks, Portrush, Co. Antrim. This species has usually been found by me on moist rocks.

Genus IV. Dimeregramma, Ralfs.

Frustules in short filaments, parallel to each other. On the front view slightly constricted near the ends; on side view elliptical, striate; the striæ marginal.

This genus, in the general appearance of its frustules, bears a strong resemblance to some of the forms included in Odontidium and Denticula, to which latter Gregory assigned the numerous forms described by him, but may be distinguished by the fact that the margin on front view presents a slight constriction at the ends.

Dimeregramma nanum, (Greg.) Marine.

Frustules on front view slightly arched, short, but broad; end of striæ appearing at the margin; on side view broadly elliptical, lanceolate; marginal striæ long, leaving but a narrow unstriated median space.

Ralfs, in Pritch., p. 790, Plate iv., fig. 33.—Dimeregramma Gregorianum, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 346. This last named author changes the specific name given by the discoverer, on the ground that the original designation answers only for the smaller forms, the species varying greatly as regards size. Rabenhorst retains the original specific name imposed by Gregory, and adopts the generic name Dimeregramma, but erroneously ascribes the species to Pritchard. Fl. Eur., sect. 1, p. 123.—Denticula nana, Gregory, Diat. of the Clyde, p. 23, Pl. x., fig. 34.

Stomachs of Ascidians, Belfast Lough, Co. Antrim.

Dimeregramma minus, (Greg.) Marine.

Frustules on front view as in the preceding species, only narrower for the length; on side view narrow, elliptical, and pointed at the ends; marginal striæ long, leaving the central unstriate band very narrow.

Ralfs, in Pritch., p. 790. Grunow, Verhand der K. K. Zool. Bot., Gesel., Band xii., 1862, p. 376, T. iv., fig. 29. Rab. Fl. Eur., sect. 1, p. 123, who attributes this species as well as the preceding to Pritchard.—Denticula minor, Gregory, Diat. of Clyde, p. 23, Pl. x., fig. 35.

On piles of wooden bridge, Dollymount. On sea-weeds, Ireland's Eye, Co. Dublin.

Dimeregramma distans, (Greg.) Marine.

Frustules on front view similar in outline to the preceding species; on side view broadly elliptical, and somewhat lanceolate at the ends; marginal striæ costate, short, leaving a broad, unstriate, median space. (Pl. 27, fig. 19.)

Ralfs, in Pritch., p. 790, Pl. iv., fig. 34. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 376. Rab. Fl. Eur., sect. 1, p. 123.—Denticula distans, Gregory, Diat. of Clyde, p. 23, Pl. x., fig. 36.

Stomachs of Ascidians, Belfast Lough, Co. Antrim.

Dimeregramma marinum, (Greg.) Marine.

Frustules on front view linear, slightly constricted at the ends; on side view linear, with cuneate ends, and slightly expanded in the middle; striæ moniliform, long, leaving the median unstriate band very narrow. This species is very much larger than the species heretofore described.

Ralfs, in Pritch., p. 790. Rab. Fl. Eur., sect. 1, p. 124.—Denticula marina, Gregory, Diat. of Clyde, p. 24, Pl. x., fig. 39.

From stomachs of Ascidians, Roundstone Bay, Co. Galway. Sea-weeds, near the Newtownlimavady junction, Co. Derry.

Genus V. Plagiogramma, Grev.

Frustules similar to those of the preceding genus, from which they are distinguished by the presence of a pair of strong, transverse costæ, including a central unstriate band. Some of the species have also, besides, a similar terminal costa at either end, the space between which and the apex is unstriate; valves striate, except at the central and terminal portions referred to; striæ sometimes interrupted in the middle, sometimes persistent; filaments short.

Plagiogramma staurophorum, (Greg.) Marine.

Valves furnished with a central pair of transverse, pervious costæ; on front view margin slightly dilated; on side view elliptical, obtuse; striæ fine, moniliform, persistent; central costæ inflexed; the unstriate band bounded by the same, narrow, and extending across the valve, from margin to margin.

Heiberg, De Danske Diat., p. 165. Cleve, Om Svenska och Norska Diat., p. 219.—Denticula staurophora, Gregory, Diat. of Clyde, p. 24, Pl. x., fig. 37. Plagiogramma Gregorianun, Grev., Q. J. M. S., July, 1859, p. 208, Pl. x., figs. 1 and 2. Ralfs, in Pritch., p. 774. Rab. Fl. Eur., sect. 1, p. 117.

On piles of wooden bridge, Dollymount, Oyster beds, Malahide, Co. Dublin. Sea-weeds, near Newtownlimavady junction, Co. Derry. Sea-weeds, Bannow, Co. Wexford. From stomachs of Ascidians, Roundstone Bay, Co. Galway.

Plagiogramma costatum, (O'M.) Marine.

Valves furnished with both a central pair of costæ and a single costa at either end; frustules in front view quadrangular; terminal constriction slight; on side view central and terminal costæ inflexed; valve broadly elliptical, with slightly-cuneate ends; central unstriate band extending across the valve; striæ costate; costæ pervious. (Pl. 27, fig. 20.)

O'Meara, Q. J. M. S., April, 1869, p. 150, Pl. xii., fig. 2.

Arran Islands, Co. Galway.

Genus VI. Diatoma, De Candolle.

Frustules united in zig-zag filaments; strongly costate; costæ pervious.

Grunow states that the various species of this genus, as well as those of Odontidium, possess fine striæ interposed between the costæ, although in the former they are more difficult to be discovered than in the latter. The most careful examination of the valves of Diatoma, on my part, has, as yet, failed to bring them out.

Diatoma vulgare, (Bory.) Fresh water.

Valves much arched, so that the costæ present a deep margin on the front view; on side view the outline is elliptical, sometimes narrowed towards the ends; costæ strong and close.

Kütz. Bac., p. 47, T. xvii., fig. 15, 1–4. Rab. Süssw. Diat., p. 35, T. ii., fig. 6. Wm. Sm., B. D., Vol. ii., p. 39, Pl. xl., fig. 309. Ralfs, in Pritch., p. 778, Pl. iv., fig. 13, Pl. ix., fig. 168. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 368. Heiberg, De Danske Diat., p. 57. Cleve, Om Svenska och Norska Diat., p. 219. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 15.

River Dodder, Grand Canal at Portobello, Co. Dublin. Well, Strokestown, Co. Roscommon. Stream in Glebe, Delgany, Co. Wicklow. River Moy, Foxford, Co. Mayo. Stream, Killeshin, Queen's County. River Lee, Co. Cork.

Diatoma grande, (Wm. Sm.) Fresh water.

Frustules on front view slightly inflexed; on side view linear, slightly constricted towards the capitate ends; costæ fine, close. (Pl. 28, fig. 1.)

Wm. Sm., B. D., Vol. ii., p. 39, Pl. xl., fig. 310. Ralfs, in Pritch., p. 779. Heiberg, De Danske Diat., p. 57. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 15.—Diatoma vulgare var. grande. Grunow, Verhand der K. K. Zool. Bot. Gesel., xii., Band 1862, p. 364.—Diatoma Ehrenbergii forma grandis, Rab. Fl. Eur., sect. 1, p. 122. Grunow stands alone in subordinating this form to Diatoma vulgare, from which it stands distinguished by numerous characters: so distinct is it from that species in the outline of the valve, both in front and side view, that it seems deserving of occupying the place of a separate species.

River at Belleek, Co. Fermanagh. Tacumshane, River Slaney, near Killurin, Co. Wexford. River Shannon, near Athlone, Co. Roscommon. Lough Corrib, Co. Mayo. Lough Derg, Co. Galway. Lough Neagh, Co. Armagh. Killikee, River Liffey, Co. Dublin.

Diatoma elongatum, (Agardh.) Fresh water.

Frustules on front view greatly inflexed; on side view linear, narrow, with capitate and expanded ends; valves not so much arched as in the preceding species, so that the costæ appear, on front view, as a row of puncta.

There is considerable diversity in the outline of various forms of this species; in some the capitate ends are not so much expanded as in others. In some the margin on side view, instead of being perfectly straight, is slightly expanded towards the middle. The species might, in some cases, be confounded with the preceding; but the characters above given will serve to distinguish between them.

Agardh, Syst., p. 4. Kütz. Bac., p. 48, T. xviii., fig. 18. Rab. Süssw. Diat., p. 35, T. ii., fig. 1. Wm. Sm., B. D., Vol. ii., p. 40, Pl. xl., fig. 311. Ralfs, in Pritch., p. 779, Pl. iv., fig. 14, Pl. ix., fig. 169. Heiberg, De Danske Diat., p. 57. Castracane, Catalogo di Diat., raccolte nell Val. Intrasca, p. 15. Cleve, Om Svenska och Norska Diat., p. 219.—Diatoma tenue var. elongatum, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 363.

Dundrum, Co. Dublin. Newcastle, Co. Wicklow. (Cork harbour. Belfast, Wm. Sm.)

Diatoma tenue, (Kütz.) Fresh water.

Frustules small; on front view regularly quadrangular; ends of the costæ appearing like a fine line of puncta; on side view broadly elliptical; ends rounded; costæ fine.

Smith makes this species a variety of Diatoma elongatum. Grunow regards it as the representative of a species of which Diatoma elongatum is a variety. A careful examination of the form, I think, will lead to the conclusion that it deserves to rank as a distinct species. In general appearance, in outline, both on front and side view, it differs from Diatoma elongatum; on front view D. elongatum is not regularly quadrangular, but somewhat inflexed at the sides, the ends being broader than the middle; whereas in D. tenue, the front view normally is perfectly quadrangular; on the side view, D. elongatum is more or less distinctly capitate, the ends being broader than the middle; the sides are usually straight and parallel; in D. tenue the side view in outline is broadly elliptical; the ends narrowed and rounded. For these reasons I consider D. tenue is obviously distinct from D. elongatum. It might more likely be considered a variety of Diatoma vulgare, but its features are perfectly distinctive. The valve of D. vulgare is greatly arched, so that the ends of the costæ occupy a large portion of the front view; whereas in D. tenue, the valve is flat, and the ends of the costæ, on the front view, are barely noticeable.

Kütz. Bac., p. 48, T. xvii., fig. 9, 10. Rab. Süssw. Diat., p. 35, T. ii., fig. 5. Ralfs, in Pritch., p. 779. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 362.—Diatoma elongatum, variety γ. Wm. Sm., B. D., Vol. ii., p. 40, Pl. xli. fig. 311 γ.

Found abundantly in a gathering from salt water at Howth, in which fresh and marine forms were mingled, the latter greatly predominating. Some cuneate forms occurred along with those in a normal state, just as described in Smith's figure; but the former are obviously to be regarded as monstrosities.

Genus VII. Ralfsia, N. G.

As Diatoma, differing only in this respect, that the valves are hyaline, and without costæ.

Ralfsia hyalina, (Kutz.) Marine.

Valves on front view quadrangular; on side view narrow, nearly linear, narrowed at ends.

Diatoma hyalinum, Kütz. Bac., p. 47, T. xvii., fig. 20. Wm. Sm., B. D., Vol. ii., p. 41, Pl. xli., fig. 312. Ralfs, in Pritch., p. 778, Pl. iv., fig. 16. Rab. Fl. Eur., sect. 1, p. 122.—Fragilaria hyalina major, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., p. 374.—Fragilaria tenerrima, Heiberg, De Danske Diat., p. 63. Cleve, Om Svenska och Norska Diat., p. 220.

Salt ditch, Breaches near Newcastle, Co. Wicklow. Sea-weeds, Tramore, Co. Waterford.

Ralfsia minima, (Ralfs.) Marine.

Frustules very small; on front view quadrangular; on side view broadly elliptical.

Diatoma minimum, Wm. Sm., B. D., Vol. ii., p. 41, Pl. xli., fig. 313. Ralfs, in Pritch., p. 778.—Diatoma hyalinum, var. minimum, Rab. Fl. Eur., sect. 1, p. 123.,—Fragilaria minima, Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 347.—Fragilaria tenerrima, Heiberg, De Danske Diat., p. 63. Cleve, Om Svenska och Norska Diat., p. 220.

Found by Ralfs attached to Surirella gemma, but found by me in a brackish ditch, Kilkee, Co. Clare, in which no specimen of Surirella gemma appeared.

Ralfsia tabellaria, N. S. Marine.

Frustules very long, ·0038; on front view regularly quadrangular; on side view capitate at the ends; gently decreasing in breadth, and then gradually expanding towards the middle. (Pl. 28, fig. 2.)

Sea-weeds, Tramore, Co. Waterford. Lough Strangford, Co. Down.

Genus VIII. Rhaphoneis, Ehr.

The characters on which this genus is grounded are:—First. The symmetry of the frustules by which they are separated from Cocconeis, which some of the species in other respects closely resemble. Secondly. They do not form parallel filaments, by which circumstance they are distinguished from those of Denticula and Dimeregramma. Thirdly. The striæ are interrupted by the interposition of an unstriate longitudinal band, more or less broad—a feature by which the forms of the genus may be discriminated from those of Diatoma and Odontidium.

While adopting this genus, I do so with somewhat of the feeling which Grunow has so well expressed in the following remarks:—"The genus Rhaphoneis, which here I represent in Ehrenberg's sense of it, is widely separated therefrom, for the purpose of receiving forms which, in point of fact, have but little generic relationship to each other. Meanwhile, it is nevertheless a sort of refuge for various Diatoms which have not been thoroughly investigated, and which, in some cases, are known only so far as their side view is concerned. A portion of these, upon more mature knowledge, may be transferred to Dimeregramma, while others, from their Cocconeis-like habit, must certainly be constituted as a special genus. Very numerous instances of forms belonging to the latter class have come under my notice; and I am convinced that they do not underlie the upper valves of Cocconeis—and for this reason, that I have never found associated with them valves of Cocconeis with a central nodule, or valves which in other details of structure would be supposed to correspond with them." Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 378. Two of the forms herein included—namely, Rhaphoneis amphiceros and Rhaphoneis rhombus, Smith has placed side by side, under the same generic name, with Doryphora Boeckii, with which, beyond the fact of being stipitate, they have little in common. Rhaphoneis amphiceros was observed by Kützing *in situ*, and described and figured by him as stipitate. I am not aware whether, in the case of the other forms included, a similar fact has been noticed. Whatever presumption there may be in favour of the supposition, this feature cannot be as yet admitted as a general characteristic of the group. Odontidium Harrisoni, Wm. Sm., the frustules of which in general structure are similar to those of Denticula, as I have defined that genus, exhibits nevertheless a different habit of growth, the frustules being attached by a cushion or short stipes, and forming a filament, the several frustules adhering by their ends to one another. It seems then in this respect, as well as in the interrupted striation, to stand in close relationship with Rhaphoneis amphiceros, and on this account I include it in the same genus; not indeed because I feel quite satisfied on this point, but because, all things considered, I regard this most suitable as a provisional arrangement.

Rhaphoneis amphiceros, (Ehr.) Marine.

On side view valves short, broadly rhomboid; very slightly produced at the apices; striæ large, moniliform, radiate; median free space linear, and very narrow, so much so as to be sometimes scarcely discernible; frustules stipitate. (Pl. 28, fig. 3.)

Ralfs. in Pritch., p. 791, Pl. xiv., fig. 21. Rab. Fl. Eur., sect. 1, p. 126.—Doryphora amphiceros, Kütz. Bac., p. 74., T. xxi., fig. 2. Wm. Sm., B. D., Vol. i., Pl. xxiv., fig. 224. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 384.

From mud on sea-shore, Co. Clare, supplied by Professor Sullivan. On Sea-weeds, Co. Clare. On Sea-weeds, Co. Donegal.

Var. leptoceros, (Ehr.) Marine.

Similar in all respects to Rhaphoneis amphiceros, but longer, narrower, and the ends produced into long beaks.

Rhaphoneis leptoceros, Ralfs, in Pritch., p. 791.

Sea-weeds, Co. Donegal; sea-weeds, Co. Clare.

Rhaphoneis rhombus, (Ehr.) Marine.

Valves narrow, elliptical; ends rounded, striæ fine; moniliform; parallel in the middle, and slightly radiate towards the ends; median unstriate space narrow, linear in the middle, and expanding towards the ends.

Ralfs, in Pritch, p. 792. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 379, T. iv., fig. 36. Roper, Q. J. M. S., Trans., Vol. ii., 1854, Pl. vi., figs. 7–10.

Concerning this form, Grunow, as above cited, makes the following noteworthy remarks:—"Rhaphoneis rhombus ought to be considered as the type of the genus Rhaphoneis, which must ever stand, though other species be separated as not belonging to it. The frustules in contradistinction to Doryphora occur free, as I consider I have satisfied myself to be the case."

Sea-weeds, Dundalk, Co. Louth. Piles of the wooden bridge, Dollymount, Co. Dublin. Sea-weeds, Co. Donegal.

A smaller variety occurs frequently in the last named gathering, much broader for the length than the ordinary specimens, but in other respects so similar that it cannot be considered even a variety.

Rhaphoneis scutelloides, (Grunow.) Marine.

Valves small, on front view broadly elliptical, rounded at the ends, stiræ obscurely moniliform, nearly parallel at the middle, and slightly radiate towards the ends; median free space, narrow, elliptical. (Pl. 28, fig. 4.)

Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 383, T. iv., fig. 34.

Sea-weeds, Co. Donegal.

Rhaphoneis lorensiana, (Grunow.) Marine.

Valves considerably larger than the last named, and in all respects similar, except that in outline the valves are rhomboid.

Grunow, Verhand, der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 381, T. iv., fig. 5.

Piles of wooden bridge, Dollymount, Co. Dublin.

Rhaphoneis liburnica, (Grunow.) Marine.

Valves broadly elliptical, almost circular; striæ large, moniliform, squarish, distinct, larger at the middle, and decreasing in size as they approach the margin, radiate; median unstriate, space narrow, elliptical. (Pl. 28, fig. 5.)

This form presents very much the appearance of a Cocconeis, in which genus I would have provisionally placed it, were it not that Grunow, who first discovered it, placed it here.

Grunow, Verhand der Zool. Bot. Gesel., Band xii., 1862, p. 383, T. iv., fig. 6.

Arran Islands, Co. Galway.

Rhaphoneis Harrisonii, (Wm. Sm.) Fresh water.

Frustules attached, filamentous, connected by their ends; on front view quadrangular; on side view somewhat cruciform; angles rounded; striæ costate, slightly radiate; median unstriate space narrow, linear.

Odontidium Harrisonii, Wm. Sm., B. D., Vol. ii., p. 18, Supp. Pl. lx., fig. 373.—Dimeregramma Harrisonii, Ralfs, in Pritch., p. 290, Pl. viii., fig. 6.—Fragilaria Harrisonii, Rab. Fl. Eur., sect. 1, p. 119.—Diatoma Harrisonii, Cleve, Om Svenska och Norska Diat., p. 219.

Friarstown, Killikee, River Dodder, Bohernabreena, Co. Dublin. Royal Canal, near Enfield, Co. Kildare. Portadown. Verner's Bridge, Co. Armagh.

Genus IX. Synedra, Ehr.

Frustules long and narrow, both on side and front view; attached by a gelatinous cushion, or by a longer or shorter stipes.

The characteristics of this genus are so well marked, that very little difference of opinion has existed from the first as to the grouping of the several species, although the relation of the genus to other genera has been very differently represented. Kützing includes Synedra in his group of Surirelleæ, in which besides he ranges the genera Campylodiscus, Surirella, and Bacillaria. The last named has, indeed, a superficial resemblance to the frustules of Synedra, but, in consequence of its unsymmetrical character, has, by more recent authors, been transferred to the Nitzschieæ; but with Campylodiscus and Surirella, Synedra has few common characteristics. Ralfs, while he adopts this grouping of Kützing, expresses dissatisfaction with an arrangement so heterogeneous, and suggests that, with more propriety, Synedra should be ranked under the Fragilarieæ. It is not very easy to ascertain precisely what Smith's views were as to the relations of Synedra; for while in the plates the Synedræ are ranged next to the Nitzschiæ, in the text they are interposed between Pleurosigma and Cocconema. For the reason already specified, the Synedræ and Nitzschiæ stand very remote from one another, in a classification based on the symmetrical or unsymmetrical structure of the frustule. And on the same ground, as well as for other reasons, I cannot consider that the right position of Synedra is in close relation either with Cocconema or Pleurosigma. Grunow, either led by the suggestion of Ralfs, or by his own sagacity, included the genus in the first sub-group of his group Diatomeæ; and although some genera which, for reasons specified before, ought not to be placed in this connexion, are included in the sub-group, still, by this arragement, the genus was associated with its natural allies. Heiberg's group of Fragilarieæ is nearly identical with Grunow's sub-group of Diatomeæ, the only difference being, that he includes in it the genus Meridion, which, in consequence of the unsymmetrical structure of its frustules, requires a different collocation. With the exceptions mentioned, I agree with Grunow and Heiberg as to the true relationship of Synedra; and in this view am sustained by the judgment of Rabenhorst also, who, though in his Süssw. Diat. he places the Synedræ between the Naviculeæ and Cuneatæ, in his more recent work, "Flora Europaea Algarum," follows the more natural grouping of Grunow and Heiberg. The frustules of Ralfsia tabellaria, regarded separately, might be considered to belong to the Synedræ, and were, indeed, regarded by me as identical with Synedra gracilis vera, not of W. Smith, but of Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 401, T. v., fig. 17, which it strongly resembles, until I had seen the frustules *in situ*, and so became convinced of my mistake. And in some cases it is difficult to distinguish between the separate frustules of some of the larger forms of Fragilaria, and some species of Synedra. I would specially refer to Fragilaria ungeraria, Grunow, the frustules of which, when detached, are scarcely, if at all, distinguishable from those of the form described by Kützing as Synedra amphirhynchus. But whatever slight confusion may arise in such cases, attention to the distinctive characteristics of the genus will readily remove it.

(a.) *Striæ pervious; frustules not arcuate on side view.*

Synedra chrystallina, (Lyngb.) Marine.

Valve very long; slightly expanded at the centre and extremities; striæ costate; costæ coarse; an intramarginal longitudinal line appears on both sides throughout the entire length. (Pl. 28, fig. 6.)

Grunow describes the stipes as short, and occasionally slightly branched. Kützing regards this species as identical with Diatoma crystallinum of Agardh, and suggests, with a note of doubtfulness, that it may be the same as Echinella fasciculata of Lyngbye. Smith confirms the former opinion, and that on the inspection of authentic specimens. Heiberg, who seems to have had the opportunity of inspecting authentic specimens of Lyngbye's species, considers it the same as the present. The species I attribute to Lyngbye, and adopt Agardh's name to obviate confusion with other species named S. fasciculata.

Kütz. Bac., p. 69, T. xvi., fig. 1. Wm. Sm., B. D., Vol. i., p. 74, Pl. xii., fig. 101. Ralfs, in Pritch., p. 789. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 407. Heiberg, De Danske Diat., p. 64. Rab. Fl. Eur., sect. 1, p. 139.—Diatoma chrystallinum, Agardh Consp., p. 52.—Echinella fasciculata, Lyngb. Tent. Hydrophyt. Dan., p. 210.

On sea-weeds, Salthill, Co. Dublin. From stomachs of Ascidians, Roundstone Bay, Co. Galway. On sea-weeds, near Dundalk, Co. Louth. On sea-weeds, Belfast Lough, Co. Antrim.

Synedra fulgens, (Greville.) Marine.

Similar to the preceding species, with which it is often associated; but may be distinguished by the greater delicacy of the striæ. The stipes as described by Kützing is long and branched. (Pl. 28, fig. 7.)

Wm. Sm., B. D., Vol. i., p. 74, Pl. xii., fig. 103. Ralfs, in Pritch., p. 789. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 408. Raben. Fl. Eur., sect. 1, p. 140. Cleve, Om Svenska och Norska Diat., p. 220.—Lichmophora fulgens, Kütz. Bac., p. 123, T. xiii., fig. 5. Kützing and Smith concur in the identification of this species with Exilaria fulgens, Greville, who has a prior claim to the authorship of this species.

Salt ditch near Wexford. Bannow, Co. Wexford. Sea-weeds, Malahide. Stomachs of Pectens, Dublin Bay. Dollymount, Co. Dublin. Stomachs of Ascidians, Co. Clare. Sea-weeds, Dundalk, Co. Louth. Sea-weeds, Belfast Lough, Co. Antrim.

Synedra baculus, (Greg.) Marine.

Similar to preceding species, but not expanded at the middle or ends as it is; striæ somewhat coarser, and without the submarginal longitudinal lines. (Pl. 28, fig. 8.)

Gregory, Q. J. M. S. Trans., Vol. v., 1857, p. 88, Pl. i., fig. 54.

Sea-weeds, Co. Clare. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Synedra superba, (Kütz.) Marine.

Frustules long on front view, quadrangular, slightly tapering at the ends; on side view tapering slightly from the middle to the broadly rounded ends; submarginal longitudinal lines strongly developed; striæ linear, coarse, and slightly waved; stipes short. (Pl. 28, fig. 9.)

Kütz. Bac., p. 69, T. xv., fig. 13. Wm. Sm., B. D., Vol. i., p. 74, Pl. xii., fig. 102. Ralfs, in Pritch., p. 789. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii. p. 406. Ralfs, in Pritch., p. 789. Cleve, Om Svenska och Norska Diat., p. 220. Rab. Fl. Eur., sect. 1, p. 139.

From stomachs of Ascidians, as well as from seaweeds, Belfast Lough, Co. Antrim. Seaweeds, Rostrevor, Co. Down. Seaweeds, near Wexford. Seaweeds, Malahide, Co. Dublin. Arran Islands, Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Synedra amphicephala, (Kütz.) Fresh water.

Frustule small and narrow, length ·0018, breadth in middle, on side view ·00015. On front view linear; on side view nearly linear in the middle, and gradually attenuated towards the slightly dilated apices; striæ very fine. (Pl. 28, fig. 10.)

Grunow places this species in association with those in which the striæ are interrupted in the middle by a longitudinal sulcus, but in the specimens which have come under my notice the striæ are obviously pervious.

Kütz. Bac., p. 64, T. iii., fig. 12. Rab. Süssw. Diat., p. 53, T. iv., fig. 28. Ralfs, in Pritch., p. 787. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 400, T. v., fig. 11. Rab. Fl. Eur., sect. 1, p. 136.

Feighcullen, Co. Kildare. Kilcool, Powerscourt, Co. Wicklow. Bantry, Well at Farraghy, Co. Cork. Tarbert, Co. Kerry.

Synedra investiens, (Wm. Sm.) Marine.

Frustules minute, length varying from ·0005 to 0020; on front view quadrangular, on side view narrow, linear, tapering towards the rounded extremities; striæ coarse and very close. (Pl. 28, fig. 11.)

Wm. Sm., B. D., Vol. ii., p. 98. Ralfs, in Pritch, p. 787. Rab. Fl. Eur., sect. 1, p. 135. The last named author places this species in a group distinguished by the fact of the striæ being interrupted by a median free space; but in a slide kindly supplied to me by Major Crozier, R. E., and described as part of the original gathering of Smith's Synopsis, the forms answering Smith's description have strong pervious costæ.

Malahide. Kingstown Harbour. Salthill, Co. Dublin.

Synedra acula, (Kütz.) Fresh water.

Frustules long and very narrow; on front view attenuated at the ends; on side view narrow, attenuated towards the ends, which are usually expanded very slightly, but frequently acute. (Pl. 28, fig. 12.)

Kütz. Bac., p. 65, T. xiv., fig. 20.—Synedra delicatissima, Wm. Sm., B. D., Vol. i., p. 72, Pl. xii., fig. 94, who represents the striæ as interrupted in the middle by a distinct median line with small central nodule, features which do not exist. Ralfs, in Pritch, p. 787. Castracane, Catalogo di Diat. raccolte nell Val. Intrasca, p. 10.—Synedra acus, var. elongata, Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii. 1862, p. 399.

Tacumshane, Co. Wexford. Stream, Crossdoney, Co. Cavan. Friarstown, Malahide, Well St. Fenton's, Sutton, Co. Dublin. Henderson's Well, Aughnacloy, Co. Tyrone.

Var. tenuissima, (Kütz.) Fresh water.

In all respects like the typical species, except that it is smaller, and much less attenuated at the ends on side view.

Synedra tenera, Wm. Sm., B. D., Vol. ii., p. 98. Ralfs, in Pritch., p. 717, who makes the form described by Smith under this name distinct from Synedra tenuissima, with which I consider it is identical.—Synedra acus, Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 398.

"Lough Alloa, near Blarney, and near Killaloe, Co. Cork," Wm. Sm., Bohernabreena, Dundrum, Boat harbour, Dolphin's barn. River Dodder, St. Fenton's Well, Sutton, Stream, Blackrock, Co. Dublin. Killeshin, Queen's County, Donoghmore, Co. Tyrone.

Synedra gracilis, (Kütz.) Marine.

Frustules small, ·0012 in length; on front view attenuated towards the ends; on side view narrow, elliptical, broader in the middle, gradually attenuated towards the rounded and slightly-expanded ends; stipes short, nearly sessile; the frustules being few and radiating slightly. (Pl. 28, fig. 13.)

Kütz. Bac., p. 64, T. iii., fig. 14, T. xiv., fig. 2 *b*, T. xv., fig. 8, 1, 2, 5. Ralfs, in Pritch., p. 786, regards this form of Kützing as identical with that so named by Wm. Smith, B. D., Vol. i., p. 70, Pl. xi., fig. 85. The forms, however, are quite distinct. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 401. It is to be remarked that the last-named author regards this species and Synedra barbatula, Kütz. Bac., p. 68, T. xv., fig. 10, as so nearly allied that the latter is to be regarded merely as a variety of the former. I cannot adopt this view, and for these reasons: first, the growth of the two is quite distinct; the frustules in Synedra barbatula are attached in tablets, while those of Synedra gracilis are fewer in number, and somewhat radiately arranged. They differ as respects the character of the striation. In Synedra barbatula the striæ are easily detected, and are divided by a narrow, longitudinal sulcus; in the smaller specimens of Synedra gracilis the striation is obscure, but in the larger forms the striæ are apparent and pervious.

From stomachs of Ascidians, Roundstone Bay, Co. Galway. From seaweeds, Drehidnamaud, Co. Kerry. Seaweeds, Salthill, Co. Dublin. Seaweeds, Tramore, Co. Waterford. Seaweeds, Greenore, Co. Louth.

(b.) *Frustules arcuate on side view, striæ pervious.*

Synedra undulata, (Bail.) Marine.

Frustules very long and narrow, with undulate margins; expanded in the middle and towards the ends; striæ moniliform. (Pl. 28, fig. 14.)

Gregory, Diat. of Clyde, p. 59, Pl. xiv., fig. 107. Wm. Sm., B.D., Vol. ii., p. 97. Ralfs, in Pritch., p. 786. Grunow, Verhand. der K.K. Zool. Bot. Gesel., Band xii., p. 405, T. vi., fig. 1. Cleve, Om Svenska och Norska Diat., p. 220. Rab. Fl. Eur., sect. 1, p. 130.—Toxarium undulatum, Bailey, Mic. Obs., p. 15, figs. 24, 25.

Grunow associates this species with forms characterised by the fact of the striæ being interrupted in the middle, and it is so represented in the figure above referred to; but I have ever found the striæ pervious, as in Gregory's figure.

Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay, Co. Galway. Stomachs of Ascidians, and also from seaweeds, in great abundance, Belfast Lough, Co. Antrim.

Synedra lunaris, (Ehr.) Fresh water.

Frustules on front view quadrangular; on side view arcuate, attenuated towards the extremities; striæ linear, fine, but distinct; stipes short. (Pl. 28, fig. 15.)

Ehr. Infus., T. xviii., fig. 4. Kütz. Bac., p. 65, T. iii., fig. 11. Wm. Sm., B. D., Vol. i., p. 69, Pl. xi., fig. 82. Rab. Süssw. Diat., p. 54, T. v., fig. 6. Ralfs, in Pritch., p. 185. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 389. Heiberg, De Danske Diat., p. 65. Rab. Fl. Eur., sect. 1, p. 128. Cleve, Om Svenska och Norska Diat., p. 220. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 10.

Lucan, Co. Dublin. Glenchree, Glenmalure, Co. Wicklow. Derrylane Lough, Co. Cavan. Bellarena, Co. Londonderry. Fivemiletown, Lisnaskea, Co. Fermanagh. Pool, Glencar, Drumoughty Lough, near Kenmare, Co. Kerry. Bantry, Co. Cork. Connemara, Co. Galway.

Synedra biceps, (Kütz.) Fresh water.

Frustules considerably larger than those of the last species; on front view quadrangular; on side view arcuate; extremities capitate. (Pl. 28, fig. 16.)

Kütz. Bac., p. 66, T. xiv., figs. 18 and 21. Wm. Sm., B. D., Vol. i., p. 69, Pl. xi., fig. 83. Rab. Süssw. Diat., p. 55, T. v., fig. 9. Ralfs, in Pritch., p. 786. Heiberg, De Danske Diat., p. 65.—Synedra flexuosa? Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 10. Rab. Fl. Eur., sect. 1, p. 129.—Synedra flexuosa, var. biceps, Grunow, Verhand. der K. K. -Zool. Bot., Gesel. Band xii., 1862, p. 390.

Killikee, Co. Dublin. Carrickmacrilly, Co. Wicklow. Glencar, Co. Kerry. Connemara, Co. Galway. Bantry, Co. Cork.

(c.) *Striæ pervious, except in the middle, where there is a free space, bounded by a more or less perfectly developed ring.*

The number of forms legitimately included in this sub-division is very limited, and still there is none, perhaps, in which greater confusion reigns. Smith includes the four following species: Synedra pulchella, Kütz., fresh water; S. gracilis, Kütz., brackish water; S. acicularis, Wm. Sm., which he makes = S. lævis, Kütz, brackish water; and S. minutissima, Kutz., fresh water. The same author excludes from this sub-division S. fasciculata, which seems really to belong to it, judging from the description given, as well as from the figure.

To look at the figures of these several species, it might be imagined there would no difficulty in distinguishing the one from the other; but, practically, the difficulty of determining is found to be considerable. Kützing's figures of them are too vague, and his descriptions too indefinite, to help the student out of the difficulty.

Grunow regards Syn. fasciculata, Kütz., as = Syn. Saxonica of the same author and Syn. gracilis, Kütz., in Wm. Sm., B. D. Syn. parvula, Kütz., he regards as = Syn. fasciculata, Kütz., Wm. Sm., B. D.; and Syn. vaucheriæ, Kütz., as = Syn. minutissima, Kütz., in Wm. Sm., B. D., as well as to Syn. vaucheriæ, Kütz., in Wm. Sm., B. D. The habitat to which these forms have been respectively assigned will furnish no satisfactory distinction. Some are attributed to fresh water, some to brackish; but when forms are ascribed to the latter, it is difficult to ascertain whether they are fresh water forms which have been carried down, or marine forms which have been carried up, or forms incidental to brackish water. Grunow has found Syn. fasciculata in salt water as well as in brackish, and likewise in the Franzensbad deposit, which is a fresh water deposit, and in which I have also found the form so named by that author; from this last fact, I conclude that the form is essentially a fresh water one, and not therefore to be discriminated on the ground of habitat from Syn. pulchella. Speaking of this last named form, Grunow sagaciously remarks, "Whether this species is actually distinct from the preceding (Syn. fasciculata, Grun. = to Syn. gracilis, Wm. Sm.), admits of considerable doubt. Single frustules are not distinguishable. The separation is founded only on the union in larger fans upon a stipes often tolerably thick, which is by no means constant, and the occurrence in fresh water." Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 392. I am disposed to regard all these various forms as merely varieties cf Syn. pulchella—and for this reason, that I have noticed them more or less mixed together in gatherings from fresh water localities, as well as in places where the water was slightly brackish, and almost always exhibiting features of mutual relationship.

Synedra pulchella, (Kütz.) Fresh water.

On front view linear, slightly attenuated towards the ends; on side view narrow, lanceolate, slightly capitate; the median ring strongly marked. (Pl. 28, fig. 17.)

I have never seen the median ring so round or so decided in its character as appears in Smith's figure of the species.

Kütz. Bac., p. 68, T. xxix., fig. 87. Wm. Sm., B. D., Vol. i., p. 70, Pl. xi., fig. 84, Supp., Pl. xxx., fig. 84. Rab. Süssw. Diat., p. 56, T. iv., fig. 17. Ralfs, in Pritch., p. 786. Grunow, Verhand. der K. K. Zool. Bot. Gésel., Band xii., 1872, p. 392. Heiberg, De Danske Diat., p. 65, who considers it a brackish water form.

River Erne, Crossdoney, Co. Cavan. Caum Lough, near Tralee. Pedler's Lake, Dingle, Co. Kerry. Kilcool, Co. Wicklow. Stream, Fintragh, Co. Donegal.

Var. gracilis, (Wm. Sm.) Fresh water.

This variety differs from the preceding only in not being constricted at the ends, and the stipes being short, the frustules scattered and not arranged in the form of a fan. In identifying this species we can go no further back than the date of Smith's work, in which it is faithfully delineated. Kützing's figures of the species named Syn. gracilis are so indistinct that it would be impossible to identify them with certainty. (Pl. 28, fig. 18.)

Synedra gracilis, Wm. Sm., B. D., Vol. i., p. 70, Pl. xi., fig. 85. Ralfs, in Pritch., p. 786, who describes the form as marine. Rab. Fl. Eur., sect. 1, p. 132, where the form is stated to be submarine, in which the author coincides with Smith.—Synedra fasciculata, Kütz. —Synedra saxonica, Kütz, according to Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., p. 391. Cleve regards this species as incidental to brackish water, and with Grunow considers it identical with Synedra fasciculata, Kütz, Om Svenska och Norska Diat., p. 220.

Stream, Port-na-Crush, Co. Donegal. Carnlough, Co. Antrim.

Breaches, near Newcastle. On moist rock, Black Castle, Co. Wicklow. Tacumshane, Co. Wexford.

Var. acicularis, (Wm. Sm.) Fresh water.

Resembling Synedra pulchella, only longer and narrower. (Pl. 28, fig. 19.)

Wm. Sm., B. D., Vol. i., p. 70, Pl. xi., fig. 86, who regards it as a brackish water form.—Synedra lævis, Kütz. Bac., p. 65, T. xv., fig. 8. 2. 3. 4. Were this the case, the variety should be attributed to Kützing, and be called var. lævis; but Kützing's figure is not sufficiently distinct to enable me to identify the variety with it, and therefore I deem it better to retain the name given by Smith, who figures it with accuracy.—Synedra Smithii, Ralfs, in Pritch., p. 786. Grunow, Verhand. der Zool. Bot. Gesel., Band xii., 1862, p. 392, who remarks, "that it is probably only a very long variety of (what he calls) Synedra fasciculata, mixed up with which he found it upon Cladophora flavida, Kütz., on the Peene at Woolgart, and in such manner that no clear distinction existed between the two." Rab. Fl. Eur., sect. 1, p. 131.

River Slaney, Killurin, Co. Wexford. Lough Gill, Co. Kerry. Carrickhugh, Co. Derry. Kilcool, moist rock, Black Castle, Co. Wicklow. In the last named locality, in which this form was found abundantly, marine influence was scarcely possible.

Var. lanceolata, (Wm. Sm.) Fresh water.

Resembling the typical form, but shorter and broader in proportion. (Pl. 28, fig. 20.)

Synedra minutissima, Wm. Sm., B. D., Vol. i., p. 70, Pl. xi., fig. 87, who ascribes the species to Kützing, but the form so called by the last named author, Bac., p. 63, T. iii., fig. 30, can scarcely be identical with it. More likely it is the same as that which Kützing describes as Synedra lanceolata: but whether or not this be the case, the designation is adopted because of its appropriateness, and the species attributed to Wm. Smith, whose figure admits of no mistake. Ralfs, in Pritch., p. 786. Heiberg, De Danske Diat., p. 65, who attributes the form to fresh or brackish water. Rab. Fl. Eur., sect. 1, p. 139.—Synedra vaucheriæ, Grunow, who adopts this view with doubtfulness, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 393, T. v., fig. 9. This last named author regards Synedra vaucheriæ, Kütz., as distinct from the form so named by Wm. Sm., and the former identical with that figured as Synedra minutissima, by Wm. Smith.

River Slaney, Killurin, Co. Wexford. River at Port-na-Crush, and stream, Fintragh, Co. Donegal. Stream, Howth, Co. Dublin. Stream near Giants' Causeway, Co. Antrim. Kilcool, Black Castle, Co. Wicklow.

Var. linearis, (Wm. Sm.) Fresh water.

Smaller than the preceding var., and on side view somewhat linear. (Pl. 28, fig. 21.)

Synedra fasciculata, Wm. Sm., B.D., Vol. i., p. 73, Pl. xi., fig. 100, who has inaccurately confounded this fresh water species with Synedra fasciculata, Kütz. Bac., p. 68, T. xv., fig. 5, which is clearly a marine species.—Synedra parvula, Kütz., according to Grunow, Verhand. der Zool. Bot. Gesel., Band xii., 1862, p. 392, T. iv., fig. 17, where the form is accurately figured; but as it is impossible to identify it with Kützing's figure of the species so named, I consider it more conducive to accuracy to refer this species to Smith, who has so accurately described it; and as his specific name must be abandoned for the reason given, and that adopted by Grunow is not quite certain, I have given it a name characteristic of its general appearance. It is to be noted that Smith separates this form from those with which it stands related; but Grunow and Rabenhorst coincide with me as to its intimate relation to the group of which Synedra pulchella is the type.

Tacumshane, Co. Wexford. Tide pool, Malahide. In both which marine and fresh water forms were mixed up, but I found it likewise mixed with the preceding variety on the surface of wet rocks at Black Castle, Co. Wicklow.

(d.) *Striæ interrupted by a narrow longitudinal sulcus; valves linear.*

Synedra capitata, (Ehr.) Fresh water.

Frustule on front view linear, expanded slightly at the ends; on side view linear, with expanded triangular head. (Pl. 28, fig. 22.)

Ehr. Infus. T. xxi., fig. 29. Kütz. Bac., p. 67, T. xiv., fig. 19. Wm. Sm., B.D., Vol. i., p. 72, Pl. xii., fig. 94. Rab. Süssw. Diat., p. 55, T. iv., fig. 6. Ralfs, in Pritch., p. 788, Pl. iv., fig. 29, and x., fig. 185. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 394. Heiberg, De Danske Diat. p. 65. Cleve, Om Svenska och Norska Diat., p. 220.

In Smith's figure there appears a short median line terminating towards the centre in small pear-shaped nodules, and also a central free space; the same features appear in the figure of Ralfs, in Pritchard, but these peculiarities do not occur in the numerous specimens which have come under my observation.

Tacumshane, Co. Wexford. Ditch at railway station, Dundalk, Co. Louth. Stream, Crossdoney, Co. Cavan. Lucan. Dundrum. Boat harbour, Dolphin's barn, Co. Dublin. Royal Canal, Enfield, Co. Meath. Royal Canal, Kilcock, Co. Kildare. Kilcool, Co. Wicklow. The Callows, Ballinasloe, Co. Galway. Limestone quarry, Mullingar, Co. Westmeath. Lough Mourne deposit.

Var. longiceps, (Ehr.) Fresh water.

Like the preceding, but longer, more slender, the ends not so large; not triangular, but rounded off. (Pl. 28, fig. 23.)

Synedra longiceps, Rab. Süssw. Diat., p. 55. Ralfs, in Pritch., p. 788. Grunow, Verhand. der K. K. Zool. Bot. Gesel. Band xii., 1862, p. 386.—Synedra notarisii, Castracane, Dialogo di Diat. raccolte nell Val. Intrasca, p. 9.

Twyford Lough, near Athlone, Co. Westmeath, unmixed with the former, and mixed with it in ditch near railway station, Dundalk, Co. Louth.

Synedra ulna, (Ehr.) Fresh water.

Frustules on front view linear; on side view linear, suddenly contracted at the ends, which are slightly constricted and rounded; striæ interrupted in the centre by a quadrangular vacant space. (Pl. 28, fig. 24.)

It is not easy to comprehend how Smith could have regarded as one species the two forms described by him under this name, B. D., Vol. i., p. 71, Pl. xi., figs. 90 and 90 *B*, than which no two forms of the genus seem to be more distinct. The result is, that great confusion has been introduced, which may be dispelled by a careful comparison of Kützing's description and figure of the species with the actual forms. It is questionable whether the form figured by Smith, as above, fig. 90 *B*, really belongs to Synedra ulna; but, unqestionably, that of fig. 90 must be excluded from its limits.

Kütz. Bac., p, 66, T. xxx., fig. 28. Rab. Süssw. Diat., p. 54, T. iv., fig. 4. Ralfs, in Pritch., p. 788, Pl. x., fig. 184, in which only the front view is given, and the mode of growth is on a short stipes, and scattered. Grunow, Verhand. der K. K. Zool. Bot., Gesel. Band xii., 1862, p. 397, where he identifies this species with Smith's fig. 90*B*, as above cited, and makes fig. 90 a variety marked by the name of lanceolata. Heiberg refers to the species as identical with that of Smith's fig. 90; De Danske Diat., p. 64. Rabenhorst Fl. Eur., sect. 1, p. 133, does not refer to Smith's figures, and follows Grunow, only that he includes Synedra salina, a very distinct species, as a variety of Synedra ulna. Castracane identifies the form so named with that of Rabenhorst Süssw. Diat., T. iv., fig. 4, as well as with that of Smith, fig. 90. Catalogo di Diat. raccolte nell Vall. Intrasca, p. 10.

Tacumshane, Co. Wexford. Caum Lough, near Tralee, Glencar, Co. Kerry. River Dodder, Co. Dublin. Ditch near Wicklow. Feighcullen, Maynooth, Co. Kildare. River Moy, Foxford, Co. Mayo. Well, Farraghy, Co. Cork.

Var. oxyrhynchus, (Kütz.) Fresh water.

Much longer than the typical species, and ends on side view sharper. (Pl. 28, fig. 25.)

Kütz. Bac., p. 66, T. xiv., fig. 11. Ralfs, in Pritch., p. 788.

Grunow makes Synedra oxyrhynchus a distinct species, which he identifies with Synedra oxyrhynchus, Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 91, and figures a variety distinguished as amphicephala, which appears identical with Synedra ulna, Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 90 *B.* The form under consideration seems different from both. Rab. Fl. Eur., sect. 1, p. 135, who follows Grunow.

River Dodder, near Dublin. River Moy, Foxford, Co. Mayo.

Var. amphirhynchus. Ehr. Fresh water.

Like the typical species, from which it differs chiefly by the absence of the quadrangular unstriate space in the centre of the valve, on side view. (Pl. 28, fig. 26.)

Kütz. Bac., p. 66, T. xiv., fig. 15. Rab. Süssw. Diat., p. 55, T. iv., fig. 7. Ralfs, in Pritch., p. 788. Grunow, Verhand. der K.K. Zool. Bot., Gesel., Band xii., 1862, p. 397.

River Moy, Foxford, Co. Mayo. Bohernabreena, River Dodder, pond, Botanic Gardens of Trinity College, Co. Dublin. Greenane, Kilcool, Powerscourt, Co. Wicklow. Feighcullen, Co. Kildare. Killeshin, Queen's County. Well, Farraghy, Co. Cork. Stream near Giants' Causeway, Co. Antrim.

Mr. Kitton of Norwich, and Rev. George Davidson, have supplied me with specimens which would appear to belong to this variety, but growing in short filaments, after the manner characteristic of Fragilaria. I find no description of the stipes in any of the authors who have referred to this form, nor have I ever seen it myself *in situ;* but not unfrequently have I noticed it aggregated in tablets, but not parallel at the ends, as if the aggregation were accidental.

Synedra longissima, (Wm. Sm.) Fresh water.

Frustules very long on front view, quadrangular; on side view linear, till near the ends, towards which it is almost imperceptibly attenuated; ends constricted and then dilated, without any central free space; valves sometimes slightly arcuate. (Pl. 28, fig. 27.)

Smith's description of this species is tolerably accurate; but the figure, B.D., Vol. i., Pl. xii., fig. 95, is calculated to mislead. The form possesses no median line, nor is there a central free space, such as this figure represents.

Wm. Sm., B. D., Vol. i., p. 72. Ralfs, in Pritch., p. 786, who asks "is this distinct from Synedra biceps?" to which I reply, certainly it is. The forms differ greatly in their general appearance, and may be discriminated by the fact that the striæ in Synedra biceps are pervious—in Synedra longissima they are separated by a median sulcus. Cleve, Om Svenska och Norska Diat., 220. Rab. Fl. Eur., sect 1, p. 130, who remarks that "it appears to him an elongated, gently-undulate form of Synedra biceps," and strangely adds, that "he considers Grunow has rightly regarded it as a variety of Synedra splendens."—Synedra splendens, var. longissima, Grunow, Verhand. der. K. K. Zool. Bot. Gesel., Band xii., 1862, p. 397. Grunow considers this form identical with Synedra biceps, Kütz. Bac., p. 66, T. xiv., figs. 18 and 21, and Rab. Süssw. Diat., p. 55, T. v., fig. 9. But however this may be, Synedra longissima and Synedra biceps are in reality distinct species.

Pond in Botanic Gardens, Belfast. Malahide. St Fenton's Well, Sutton. Streamlet, Newcastle Lyons, Co. Dublin. Twyford Lake, near Athlone, Lake Belvidere, Co. Westmeath. Ditch near railway station, Dundalk, Co. Louth. Ditch near Wicklow.

Synedra obtusa, (Wm. Sm.) Fresh water.

Similar to the preceding species, but much shorter; not so much constricted or expanded at the rounded ends. (Pl. 28, fig. 28.)

Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 92, who regards it as = Synedra ulna, Ehr. Inf., T. xvii., fig. 1; but of this he is doubtful; and Synedra æqualis, Kütz. Sp. Alg., p. 45, ad speciem quæ dedit amico De Brèbisson. If Synedra æqualis, Kütz., just referred to, be the same as that described by the same author, Bac., p. 66, T. xiv., fig. 14, it is scarcely identical with the present species.—Synedra splendens, var. obtusa, Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 397.—Synedra splendens, var. æqualis, Rab. Fl. Eur., sect. 1, p. 134. The linear form of the side view appears to me to distinguish this from the form named Synedra splendens by both the authors last referred to, which Grunow describes as generally, small lanceolate, and less frequently linear, and Rabenhorst as linear, lanceolate. If this form can be regarded as a variety of any other, I think it should be of Synedra longissima, which it very closely resembles.

Tacumshane, Co. Wexford; Ditch near railway station, Londonderry. Limestone quarry, Mullingar. Twyford Lake, near Athlone. Lake Belvidere, Co. Westmeath.

(e). *Striæ interrupted by a narrow, longitudinal sulcus; valves, narrow elliptical.*

Synedra splendens, (Kütz.) Fresh water.

Frustules long: on front view usually wider at the ends than in the middle; on side view, narrow elliptical, gradually attenuated to the slightly capitate ends. (Pl. 28, fig. 29).

I have found it impossible to discriminate between this species and Synedra ulna, as described by Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 90. The latter species, as described by Kützing Bac., p. 66, T. xxxx., fig. 28., is on side view perfectly linear; and although I have occasionally seen specimens which exhibit a tendency towards the elliptical outline, I am disposed to regard these as abnormal, the normal character being linear. Smith indeed distinguishes the two forms by the fact that, in the latter, the frustules are loose and scattered, whereas in the former they are arranged radiately; and, although such a feature of growth is not to be wholly overlooked, it is scarcely sufficient to distinguish the species, especially in the earlier stages of growth, where the frustules are few in number. I am inclined to think the form which Smith describes as Synedra ulna is really Synedra splendens. It seems strange that this form should have been attributed to Wm. Smith, although he regards what he calls Synedra radians as equivalent to Synedra splendens, Kütz.

Kütz., Bac., p. 66, T. xiv., fig. 16; Rab. Sussw. Diat., p. 54, T. iv., fig. 4? Ralfs, in Pritch., p. 788. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., p. 394.—Synedra radians, Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 89. Heiberg, De Danske Diat., p. 64. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 10. Cleve, Om Svenska och Norska Diat., p. 220.

Stream, Crossdoney. Derrylane Lough, Co. Cavan. Lucan. Friarstown, Bohernabreena, Malahide, Co. Dublin. Tacumshane, Co. Wexford. Killeshin, Queen's Co. Royal Canal, Enfield, Co. Meath. Glencar. Pedlar's Lough, near Dingle, Co. Kerry. Ditch near railway station, Dundalk, Co. Louth. River Suck, Ballinasloe, Co. Galway.

Var. radians, (Kütz.) Fresh water.

Like the typical species, but smaller, and the ends more acute on side view. (Pl. 28, fig. 30.)

Kütz. Bac., p. 64, T. xiv., fig. 7. Ralfs, in Pritch., p. 787.—Synedra radians, Wm. Sm., B. D., Vol. i., p. 71, Pl. xii., fig. 89 B, and 89 y.

Friarstown, Co. Dublin. Derrylane Lough, Co. Cavan. Pedlar's Lough, near Dingle, Co. Kerry. Ditch near Dundalk, Co. Louth. Ditches in the Callows, Ballinasloe, Co. Galway.

Var. danica, (Kütz.) Fresh water.

Frustules longer and narrower than the typical species, the striation finer, and the valves on front view more gradually attenuated towards the ends, which are broadly rounded off, and not capitate. (Pl. 28, fig. 31.)

Kütz. Bac., p. 66, T. xiv., fig. 13.—Ralfs, in Pritch., p. 788; Synedra radians var. debilis, Rab. Fl. Eur., sect. 1, p. 134? Grunow considers this var. = Synedra radians, Wm. Sm., B. D., Vol. i., p. 71, Pl. xii., figs. 89 B, and 89 y; Verhand. der K. K. Zool. Bot., Gesel., Band xii., p. 396; but Synedra danica is much longer than that variety, less lanceolate, and with broader rounded apices.

River Moy, near Foxford, C. Mayo. Bantry Well, Farraghy, Co. Cork. Donoughmore, Co. Tyrone. Coolnamuck, parish of Dysert, Co. Waterford.

Synedra salina, (Wm. Sm.) Marine.

Valve lanceolate, gradually attenuated towards the ends, which are rounded off, and broader than in Synedra splendens. (Pl. 28, fig. 32.)

Wm. Sm., B. D., Vol. i., p. 71, Pl. xi., fig. 88. Ralfs, in Pritch., p. 787. Grunow, Verhand. der K. K. Zool. Bot. Gesel. Band xii. p. 398.—Synedra ulna, var. marina Rab. Fl . Eur., sect. 1, p. 134.

Tacumshane, Co. Wexford. Malahide, Clontarf, Co. Dublin. Rostrevor, Co. Down. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Synedra gallionii, (Ehr.) Marine.

Frustules on front view slightly attenuated at the ends, on side view shorter, broader, and more obtuse at ends than in case of Synedra salina. (Pl. 28, fig. 33.)

Kütz. Bac., p. 68, T. xxx., fig. 42. Wm. Sm., B. D., Vol. i., p. 74. Supp. Pl. xxx., fig. 265, who describes a shorter and stouter var. *ib.*, Supp. Pl. xxx., fig. 265 B. Ralfs, in Pritch, p. 788, Pl. xii., figs. 34–36. Grunow, Verhand der K. K., Zool. Bot. Gesel., Band xii., 1862, p. 401. Rab. Fl. Eur., sect. 1, p. 137, who attributes the species to Bory.

On seaweeds, Bannow, and Tacumshane, Co. Wexford. On seaweeds, Malahide, Co. Dublin. Seaweeds, Larne, Co. Antrim. Seaweeds, Dundrum Bay, Co. Down. Arran Islands, Co. Galway, and from seaweeds at different parts of the coast in the Co. Clare.

The smaller variety has been found at Malahide, Howth, Co. Dublin. On seaweeds, Larne, Co. Antrim, and in the other localities where the larger species has occurred.

Synedra spathulata, N. S. Fresh water.

Frustules very large; length, ·0130; on front view wider at ends than middle; greatest breadth, ·0012; ends straight; on side view wider in the middle, and gradually attenuated towards the ends, at some distance from which ·0028, bending inwards and then outwards, then suddenly constricted towards the broadly capitate rounded extremities. Striæ course, costate. (Pl. 28, fig. 34.)

Ditch at bank of Royal Canal, near Kilcock, Co. Kildare. An undulate variety of the species occurs in a well, Newcastle, Lyons, Co. Dublin.

Synedra barbatula, (Kütz.) Marine.

Frustules short, on front view quadrangular; on side view broadly elliptical; striæ fine, but distinct. (Pl. 28, fig. 35.)

Kütz. Bac., p. 68, T. xv., fig. 104. Ralfs, in Pritch., p. 789.—Synedra gracilis, var. barbatula, Grunow, Verhand. der K.K. Zool. Bot., Gesel., Band xii., p. 402.

Salthill, Co. Dublin. Stomachs of Ascidians, Roundstone Bay, Co. Galway. Seaweeds, Tramore, Co. Waterford.

(f.) *Striæ marginal.*

Synedra tabulata, (Agardh.) Marine.

Frustules large, adhering in tablets on a short stipes; on front view wider at middle than at the ends; on side view nearly linear, very slightly attenuated towards the constricted and rounded ends; striæ broader than in the succeeding species. (Pl. 28, fig. 36.)

Kütz. Bac., p. 68, T. xv., figs. 101–3, where the form is described more in accordance with my specimens than that of Wm. Sm., B. D., Vol. i., p. 72, Pl. xii., fig. 96. Ralfs, in Pritch., p. 788; Grunow, Verhand. der K. K. Zool. Bot., Gesel., Band xii., 1862, p. 403. Rab. Fl. Eur. Alg., sect. 1, p. 137. Cleve, Om Svenska och Norska Diat., 220. According to Kützing = Diatoma tabulatum, Agardh, on which authority I attribute the species to Agardh, as do also Ralfs and Rabenhorst, while Smith, Cleve, and Grunow, the latter doubtfully, refer it to Kützing.

On seaweeds, Bannow, Co. Wexford, as well as on seaweeds near the town of Wexford. Seaweeds, Rostrevor, Co. Down. Seaweeds, Malahide, Co. Dublin. Laytown, Co. Meath. Breaches near Newcastle, Co. Dublin. Seaweeds, Larne, Co. Antrim.

Synedra arcus, (Kütz.) Marine.

Frustules much smaller than those of the preceding species, and not dissimilar in their mode of growth; on front view slightly arcuate; on side view slightly sigmoid; striæ short. (Pl. 28, fig. 37.)

Kütz. Bac., p. 68, T. xxx., fig. 50. Wm. Sm., B. D., Vol. i., p. 70, Pl. xi., fig. 98, Pl. xii., fig. 98, in which latter the front view and manner of growth are accurately depicted. Ralfs, in Pritch., p. 789, Pl. iv., fig. 27, where the front view is represented as straight and perfectly quadrangular, and the side view as arcuate, and with a median line, the striæ reaching the latter; in all these particulars the figure is not correct. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., p. 405. Heiberg, De Danske Diat., p. 65. Rab. Fl. Eur., sect. 1, p. 138.

On seaweeds, Malahide, Monkstown, Bray, Co. Dublin.

Synedra affinis, (Kütz.) Marine.

Frustules in mode of growth similar to the preceding; on front view attenuated at ends; on side view lanceolate; striæ short. (Pl. 28, fig. 38.)

Kütz. Bac., p. 68, T. xv., fig. 6. Wm. Sm., B. D., Vol. i., p. 73, Pl. xii., fig. 97. Ralfs, in Pritch., p. 788. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 403. Rab. Fl. Eur., sect. 1, p. 138.

Tide-pool, Wexford. Tacumshane, Co. Wexford. On sea-weeds, Malahide and Clontarf, Co. Dublin. Camlough Bay, Co. Antrim.

Rostrevor and Dundrum Bay, Co. Down. Breaches near Newcastle, Co. Wicklow. Mouth of the Nannywater, Laytown, Co. Meath.

Synedra nitzschiodes, (Grun.) Marine.

Frustules on front view slightly attenuated towards the ends; on side view narrow, linear lanceolate. (Pl. 28, fig. 39.)

Grunow does not describe the mode of growth, nor can I say anything on this subject, as the form has been observed by me only after treatment with acid. This species may be distinguished from the last by the linear and slightly apiculate form of the side view.

Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., p. 403, T. v., fig. 18. This species was found by Grunow only in the Pacific Ocean.

From stomachs of Ascidians, Roundstone Bay, Co. Galway. From seaweeds, Rush, Co. Dublin, where it occurs in tolerable abundance.

Synedra frauenfeldii, (Grun.) Marine.

Frustules much larger than the three preceding species on front view, but very slightly attenuated at the ends; on front view narrow, lanceolate, much attenuated from the middle towards the ends, which are slightly dilated; striæ fine, marginal in the middle, but as the valves become narrow towards the ends, they seem to meet. (Pl. 28, fig. 40.)

Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 406, T. iv., fig. 26. The only habitat given by Grunow is the Red Sea.

Seaweeds, Dundalk, Co. Louth. The form is more slender than that figured by Grunow as above, the apex less dilated, and the striæ shorter; but in the main features the forms are so like as to leave but little doubt of their identity.

Synedra putealis, N. S. Fresh water.

Frustules in length ·0045, very narrow; on front view slightly attenuated towards the ends; on side view narrow, lanceolate, gradually tapering towards the rostrate ends; striæ short; stipes short; on which the frustules are crowded in small tablets containing about ten in each. (Pl. 28, fig. 41.)

This form possibly may be identical with that described as Synedra tenuis, by Kützing, Bac., p. 65, T. xiv., fig. 10, but in some respects it is so different as to warrant the conclusion that it is specifically distinct. Kützing does not describe the mode of growth nor the character of the striæ, and moreover alleges that in the species referred to, the frustules are exactly linear on front view, whereas in the present case they are obviously attenuated.

St. Fenton's Well, Sutton, Co. Dublin. Well near the Roman Catholic Chapel, Ballinasloe, in both which localities it occurs in great abundance, mixed with other forms.

Synedra Smithii, N. S. Fresh water.

Frustules small; on front view quadrangular; on side view narrow, linear; accuminate at the ends; striæ short. (Pl. 28, fig. 42.)

Synedra vaucheriæ, Wm. Sm., B. D., Vol. i., p. 73, Pl. xi., fig. 99, who identifies the species with that so named by Kützing, Bac., p. 65, T. iv., fig. 4, 1, 2*a*, 3; and so far as the description of it is concerned, not without warrant: but although in some respects the figures cited seem to agree with the form under notice, in other respects there is such a difference as to cast a doubt on the correctness of the identification. Kützing represents the striation in his form as pervious, whereas in that figured and described by Smith the striæ are marginal and very short. Rabenhorst describes and figures a form under the name of S. vaucheriæ; but although from the description it might fairly be supposed to be the same as the present form, the figure renders the identity more than doubtful; Süssw. Diat., p. 55, T. iv., fig. 15. Again, Grunow describes a form as identical with Kützing's Synedra vaucheriæ; Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 393, T. v., fig. 9, which seems to differ widely from Kützing's figure, as well from that so named by Wm. Smith. He remarks:— "The species here referred to, which exhibits a decided relationship to Synedra pulchella, I regarded for a long time as the identical Synedra vaucheriæ of Kützing and recently had my impression on the subject confirmed through means of some specimens of De Brèbisson's, kindly sent to me by Professor A. Braun. I find Smith's figure widely different from Synedra vaucheriæ, Kütz., which might much rather be regarded as a form of Synedra affinis, although Synedra vaucheriæ also possesses a tolerably broad unstriate space between the striæ, but in the description I find no allusion to the unstriate very fine ring-formed-pseudo-nodule." These remarks make it obvious that it is impossible to identify Smith's form with Synedra vaucheriæ, Kütz., from which it differs considerably. I have therefore adopted a new specific name, that of Synedra Smithii.

Tacumshane, Co. Wexford. River at Port-na-Crush, Co. Donegal. Malahide, Portmarnock, St. Fenton's Well, Sutton, Co. Dublin.

(g.) *Striæ obsolete.*

Synedra debilis, (Kütz.) Fresh water.

Frustules very minute; on front view regularly quadrangular; on side view elliptical-lanceolate. (Plate 28, fig. 43.)

Kütz. Bac., p. 65, T. iii., fig. 45. Ralfs, in Pritch., p. 787.—Synedra radians, var. debilis, Rab. Fl. Eur., sect. 1, p. 136.

Twyford Lake, near Athlone, Co. Westmeath. River Dour, Co. Cork.

FAMILY VI. STRIATELLEÆ, Kütz.

Frustules precisely as in the immediately preceding family, and distinguished by the possession of internal diaphragms, which, springing from the connecting membrane, are interposed between the two opposite valves.

This family, since it was constituted by Kützing, has been adopted by successive authors, but with some divergence respecting the species comprehended within its limits. As here defined, it embraces not only the genera included in Kützing's family Striatelleæ, but also those of the family Tabellaricæ, which, though generically distinct, come properly within the same limits. The Genera Gephyria and Eupluria, which were included by Ralfs, are here excluded from the family; because in whatever other respects they may agree, they stand remote in consequence of the unsymmetrical structure of the opposite valves. And for a similar reason I exclude Podosphenia, which Heiberg placed in the family, the frustules being unsymmetrical both on front and side view.

Thus defined, the family is precisely equivalent to Grunow's subgroup of Diatomeæ, and stands out distinguished by two very decided features, namely, the perfect symmetry of the valves, and the interposition between them of diaphragms more or less numerous.

The diaphragms constitute so important a feature in the family, that some observations are needed to explain their nature and mode of growth. As far as I know, Ralfs was the first who described these organs with any tolerable approach to accuracy. He says:—"The appearance of longitudinal striæ is in fact produced by silicious plates, arising internally from the margins of the filament, and extending towards, but not reaching, the centre. The interior is thus divided into chambers opening into a central space. When viewed laterally, this central space resembles a canal, especially as the inner edge of each plate has a concave outline." Ralfs, in Pritch., p. 803. If there be anything vague in this description, it is greatly elucidated by the observations of Wm. Smith, as well as by the figures of these diaphragms in the case of Rhabdonema, Tetracyclus, and Tabellaria, B. D., Vol. ii., pp. 32–34, Pl. xxxviii., fig. 306 h and 305†, Pl. xxxix., fig. 308 h and h′, Pl. xliii., fig. 316† and 317†.

In these cases, the diaphragms may be regarded as compressed rings corresponding externally with the outline of the valves; but Heiberg has called attention to the fact that, in the case of Striatella, the diaphragms are somewhat differently constructed. "Smith's representation of the structure of this species is in the main correct, but he has misapprehended the form of the diaphragms, considering them to be closed rings (as his figure 307 h, as well as the descriptive term, "Annuli" indicate), whereas in reality they are open at one end. The form of them would naturally be best seen by preparing them out separately. One can, however, satisfy himself that the diaphragms are open at one end, by observing a perfect frustule in transverse view, when one diaphragm is seen from the open, and the other from the closed, side."—De Danske Diat., p. 72. In the case of the diaphragms of Striatella, it may be noticed that the silicious plate is thicker at one end, and becomes gradually thinner as it recedes from it. This fact may serve to illustrate the mode of growth in the diaphragms in other species, as well as in Striatella. Springing from opposite ends, the two contiguous diaphragms in some cases appear much thicker at the starting point, and as they proceed parallel to each other become thinner and thinner as they approach the opposite end of the frustule. The strong lines which appear as costæ on the front view may seem to mark the extreme length to which the diaphragms project into the cell; but the compressed rings are, except in the case of Striatella, complete, and can by proper focusing be traced through their entire course.

Genus I. Grammatophora, (Ehr.)

Frustules attached, united in zig-zag filaments; diaphragms two in number; open in the centre, and equally developed at both sides of the same. Valves narrow, elliptical; sometimes slightly expanded in the middle; striæ obvious, and appearing on front view as a narrow striate border.

Although the species of this genus are by the experienced eye easily discriminated, it is not easy to describe their characteristics in words so as satisfactorily to obviate confusion with other forms belonging to the same family, especially with Tabellaria, which they resemble, not only in the mode of growth in zig-zag filaments, but also in the general formation of the diaphragms, which are equally developed on both sides of the central portion. Whether we view the frustules on the front or side views, they may be distinguished by the following characters:—In Grammatophora the valves are sometimes slightly expanded in the middle, but in no case so much so as in Tabellaria; the striæ, too, are ever noticeable, which is not the case with the last-named genus. And on the front view the narrow margin of striæ noticeable in the species of Grammatophora are never to be seen in those of Tabellaria.

Grammatophora marina, (Lyngb.) Marine.

Frustules on front view regularly quadrangular; on side view narrow, elliptical; striæ obvious; diaphragms curved near the ends, and thence running in a straight line towards the middle. (Pl. 29, fig. 1.)

Kutz. Bac., p. 128, T. xvii., fig. 24, who regards the species as identical with Diatoma marina, Lyngb. Wm. Sm., B. D., Vol. ii.,

p. 42, Pl. xlii., fig. 314. Ralfs, in Pritch., p. 808, Pl. iv., fig. 47, Pl. xi., fig. 52 and 53. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band. xii., 1862, p. 415. Heiberg, De Danske Diat., p. 71. Rab. Fl. Eur., s. 1, p. 303. Cleve, Om Svenska och Norska Diat., p. 222.

Sea-weeds, Malahide. Sea-weeds, Portmarnock, Co. Dublin. Sea-weeds, Portrush; and same, Co. Antrim. Arran Islands, Co. Galway. Tacumshane, Co. Wexford.

Grammatophora macilenta, (Wm. Sm.) Marine.

Frustules on front view quadrangular, but sometimes slightly arcuate; generally much longer than the preceding species; on side view nearly linear; diaphragms similar to the last, except that the foramen is more elliptical, and the striæ finer.

Wm. Sm., B. D., Vol. ii., p. 43. Supp. Pl. lxi., fig. 382. Ralfs, in Pritch., p. 808. Rab. El, Eur., sect. 1, p. 304. Cleve, Om Svenska och Norska Diat., p. 222.—Grammatophora oceanica, var. macilenta, Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 417.

Salt ditch, near Wexford. Tacumshane, Co. Wexford. Carnlough Bay, Portrush. Waterfoot, Co. Antrim. Dundrum Bay, Co. Down. Arran Islands, Co. Galway.

Grammatophora serpentina, (Ralfs.) Marine.

Frustules on front view regularly quadrangular; on side view linear elliptic; striæ obvious; diaphragms undulate, and seen on front view spiral. (Pl. 29, fig. 2.)

Kütz. Bac., p. 129, T. xxix., fig. 82. Wm. Sm., B. D., Vol. ii., p. 43, Pl. xlii., fig. 315. Ralfs, in Pritch., p. 808, Pl. iv., fig. 48. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 420. Rab. Fl. Eur., sect. 1, p. 304. Cleve, Om Svenska och Norska Diat., p. 222.—Striatella serpentina, Ralfs. An. Nat. Hist., Vol. ii., Pl. ix., fig. 5.

Malahide, Co. Dublin. Sea-weeds near town of Wicklow. Tacumshane, Co. Wexford. Portrush, Co. Antrim. Arran Islands, Co. Galway.

Grammatophora balfouriana, (Wm. Sm.) Fresh water.

Frustules small; on front view quadrangular; on side view linear, elliptical; diaphragms direct, without curvature; striæ fine.

Ralfs, following Greville, establishes a new genus Diatomella to receive this single form, and is followed in this view by Grunow and Rabenhorst; but, as it appears to me, the characters are not such as to distinguish the new genus from Grammatophora.

Wm. Sm., B. D., Vol. ii., p. 43, Supp. Pl. lxi., fig. 383. Ralfs, in

Pritch., p. 810, Pl. iv., fig. 51, 52. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 319. Rab. Fl. Eur., sect. 1, p. 300.

Lough Derg, Co. Galway. Ulster Canal, near Newry, Co. Armagh. Only a few forms were found in these localities, the species being one of the rarest in Ireland.

Genus II. Tabellaria, Ehr.

Frustules attached in zig-zag filaments; valves expanded at the middle and ends; striæ faint.

Tabellaria flocculosa, (Roth.) Fresh water.

Diaphragms numerous, thickened ends alternately placed, and varying in length. (Pl. 29, fig. 3.)

Kütz. Bac., p. 127, T. xvii., fig. 21. Rab. Süssw. Diat., p. 63, T. x., fig. 2. Wm. Sm. B. D., Vol. ii., p. 45, Pl. xliii., fig. 316. Ralfs, in Pritch., p. 807, Pl. xiii., fig. 29. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 410. Heiberg, De Danske Diat., p. 70. Castracane, Catalogo di Diat. raccolte nell Val Intrasca, p. 15. Cleve, Om Svenska och Norska Diat., p. 221.—Tabellaria ventricosa, Kütz. Bac., p. 127, T. xxx., fig. 74, does not differ from the present species.

Frequent, especially in sub-Alpine and boggy pools. Kützing regards this species as identical with Conferva flocculosa, Roth., on which authority the species is attributed to Roth.

Tabellaria fenestrata, (Lyngb.) Fresh water.

Diaphragms few, and of equal thickness on both sides of the central expansion; frustules much longer than in the preceding species.

Kütz. Bac., p. 127, T. xvii., fig. 22, T. xviii., fig. 2, and T. xxx., fig. 73, who regards the species as identical with Diatoma fenestratum Lyngbye. Rab. Süssw. Diat., p. 63, T. x., fig. 1. Wm. Sm., B. D., Vol. ii., p. 46, Pl. xlviii., fig. 317. Ralfs, in Pritch, p. 807. Grunow, Verhand. der K.K. Zool. Bot. Gesel., Band xii., 1862, p. 410. Heiberg, De Danske Diat., p. 71. Castracane Catalogo di Diat. raccolte nell Val Intrasca, p. 16. Cleve, Om Svenska och Norska Diat., p. 321.

Common in the same localities as the preceding, with which it is usually mixed.

Genus III. Tetracyclus, Ralfs.

Frustules united in parallel filaments; filaments free; thickened ends of the diaphragms alternate; valves much expanded in middle; strongly costate; costæ pervious.

Tetracyclus lacustris, (Ralfs.) Fresh water.

Middle expansion of the valve rounded. (Plate 29, fig. 4.)

Ralfs, Ann. Nat. Hist., Vol. xii., 1843, Pl. ii., fig. 2. Kütz. Bac., p. 127, T. xxix., fig. 70. Rab. Süssw. Diat., p. 68, T. ix., fig. 1. Wm. Sm., B. D., Vol. ii., p. 38, Pl. xxxix., fig. 308. Ralfs, in Pritch, p. 806, Pl. viii., fig. 10, and Pl. xi., fig. 24, 25. Grunow, Verhand der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 412. Cleve, Om Svenska och Norska Diat., p. 222.

River Erne, Crossdoney, Co. Cavan. Lake near Castlewellan, Co. Down. River Bann, Verner's Bridge, Co. Armagh. Tonabrick Mountain, Co. Cork; Wm. Smith.

Tetracyclus emarginatus, (Ehr.) Fresh water.

"Valves constricted towards the extremities, which are rounded and sub-apiculate; inflections deeply notched or emarginate; otherwise like the last species."—Wm. Smith.

Wm. Sm. B. D., Vol. ii., p. 38. Ralfs, in Pritch., p. 806. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 412. Rab. Fl. Eur., sect. 1, p. 302. Cleve, Om Svenska och Norska Diat., p. 222. Smith supposes this species identical with Biblarium emarginatum, Ehr. Mic. T. xxxiii. 2, fig. 6. On his authority I attribute the species to Ehrenberg.

Gap of Dunloe, Killarney. Wm. Smith. This species is extremely rare, not a single specimen having ever come under my notice from any locality in Ireland.

Genus IV. Rhabdonema, Kütz.

Stipes short; diaphragms numerous, on the external margin strongly costate, broad; extremity of the valves unstriate.

Smith alleges that in this genus the valves have a median line, a statement which does not appear to be sustained by the facts of the case.

Rhabdonema arcuatum, (Lyngb.) Marine.

Frustules short; on side view broadly elliptical; costate, with moniliform striæ interposed between the costæ; striæ pervious; diaphragms numerous, parallel, with a single foramen. (Pl. 29, fig. 5.)

Kütz. Bac., p. 126, T. xviii., fig. 6, who states that the species is identical with Diatoma arcuatum, Lyngbye, Wm. Sm. B. D., Vol. ii., p. 34, Pl. xxxviii., fig. 305. Ralfs, in Pritch., p. 804. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., p. 423. Heiberg, De Danske Diat., p. 70. Rab. Fl. Eur., sect. 1, p. 306. Cleve, Om Svenska och Norska Diat., p. 221.

Salt ditch, near Wexford. Tacumshane, Co. Wexford. Malahide, Ballybrack, Co. Dublin. Carnlough Bay. Sea-weeds, Portrush, Co. Antrim. Sea-weeds, Dundalk, Co. Louth. Sea-weeds near Galway town. Arran Islands, Co. Galway.

Rhabdonema minutum, (Kütz.) Marine.

Valves small; expanded in the middle; attenuated towards the rounded ends; striæ moniliform, pervious; diaphragms few; apparently alternate, with a single foramen.

Kutz. Bac., p. 126, T. xxi., fig. 2, 4. Wm. Sm., B. D., Vol. ii., p. 35, Pl. xxxviii., fig. 306. Ralfs, in Pritch., p. 804, Pl. iv., fig. 41. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 423. Heiberg, De Danske Diat., p. 70. Rab. Fl. Eur., sect. 1, p. 306. Cleve, Om Svenska och Norska Diat., p. 221.

Sea-weeds, Malahide; on piles of wooden bridge, Dollymount Strand, Ballybrack, Salt Hill, Co. Dublin. Sea-weeds, Portrush. Larne, Co. Antrim. Tacumshane, Co. Wexford. Dundalk, Co. Louth.

Rhabdonema adriaticum, (Kütz.) Marine.

Frustules very large; valves narrow, linear elliptical; striæ moniliform; diaphragms numerous, not so wide on margins nor so strongly costate as on R. arcuatum, with two or more foramina.

Kütz. Bac., p. 126, T. xviii., fig. 7. Wm. Sm., B. D., Vol. ii., p. 35, Pl. xxxviii., fig. 305 a, b. Ralfs, in Pritch., p. 805, Pl. xiii., fig. 27. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 424. Rab. Fl. Eur., sect. 1, p. 306. Cleve, Om Svenska och Norska Diat., p. 221.

Malahide, Co. Dublin. "Cork Harbour. Belfast Bay, near Carrickfergus." Wm. Smith.

Genus V. STRIATELLA, Agardh.

Frustules stipitate; stipes long; valves elliptical, lanceolate, with a median line, without central or terminal nodule; striæ obsolete; diaphragms numerous, on front view linear, unstriate, strongly marked at one end, and gradually attenuated towards the other; not reaching the entire breadth of the valves; arranged alternately; on side view not reaching the full length of valve; open the greater part of the length.

Striatella unipunctata, (Lyng.) Marine.

Diagnosis same as that of the genus. (Pl. 29, fig. 6.)

Kütz. Bac., p. 125, T. xviii., fig. 5, who considers the form identical with Fragilaria unipunctata, Lyngbye. Wm. Sm., B. D., Vol. ii., p. 36, Pl. xxxix., fig. 307. Ralfs, in Pritch., p. 803, Pl. iv., fig. 40. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 427. Heiberg, De Danske Diat., p. 72. Rab. Fl. Eur., sect. 1, p. 307. Cleve, Om Svenska och Norska Diat., p. 222.

Sea-weeds, Bray, Howth, Salt Hill, Co. Dublin. Stomachs of Ascidians, Co. Clare. Sea-weeds, Co. Galway. "Larne and Belfast Bays, Cork Harbour," Wm. Smith.

Genus VI. Tessella, Ehr.

Frustules stipitate, stipes short; not filamentous; diaphragms apparently reaching not further than the middle of the valve, alternate, arched, and in opposite directions on the opposite sides of the frustule; external edges of the diaphragms slightly striate.

Tessella interrupta, (Ehr.) Marine.

Diagnosis of the species same as that of the genus. Of the side view of this species, I have never been able to obtain a satisfactory observation. (Pl. 29, fig. 7.)

Kütz. Bac., p. 125, T. xviii., figs. 41, 2. This author states with hesitation that there is no stipes in this species, as also does Ralfs, in Pritch., p. 804, Pl. vii., fig. 5.—Striatella interrupta, Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 427. It is to be noticed that this species cannot be confounded with Striatella interrupta, as described and figured by Heiberg, De Danske Diat., p. 75, T. v., fig. 15, and Rab. Fl. Eur., sect. 1, p. 307.

Sea-weeds, Co. Galway. Sea-weeds, Co. Clare; in both which localities it occurs in company with Striatella unipunctata.

Family VII. AMPHIPLEUREÆ, Kütz.

Frustules free; lanceolate on side view, with median line and long narrow end nodules, but without central nodule, and exhibiting a submarginal keel at each side.

Genus I. Amphipleura, Kütz.

The characters of this genus may be regarded as those of the family. It will be found that the structure of the frustules in this genus has not hitherto been described with sufficient accuracy for their satisfactory diagnosis, and consequently its relations with other genera have been very variously represented. Kützing includes it among the Naviculeæ; Smith places it between Amphiprora and Navicula, while Ralfs, Grunow, and Heiberg, agree in assigning to it a position of near relationship to the Nitzschieæ. The remarks of the last named author are noteworthy:—"Amphipleura is a genus which stands in need of a more precise revision. Grunow, in his first treatise, placed the genus in the group Surirelleæ, with which it has no very close relationship; but subsequently this author established the genus as the type of a special group, Amphipleureæ, and at the same time gave a valuable contribution towards a more precise limitation of the genus: but notwithstanding, much remains still to be done. I have placed the genus with the Nitzschieæ, because Amphipleura sigmoidea, the only species thoroughly examined by me, seems to agree essentially with Nitzschia, and in fact to possess the same unsymmetrical relation of the connecting membrane with the front view. As to the other of the undernamed species (Amphipleura pellucida), I have not as yet had sufficient material to institute a more exact examination, and have been able only to satisfy myself as to its identity with the species of the author named."—De Danske Diat., p. 116. The above remarks indicate the source of the confusion which exists, namely, the supposition that the form described as Amphipleura sigmoidea belongs to the genus Amphipleura; I regard it as not at all distinguishable from Nitzschia sigma. Assigning this latter form to its proper place, we have a distinct and satisfactory diagnosis of the genus Amphipleura, founded on the presence of the median line without a central nodule, and the elongated character of the end nodules, as well as the presence of the submarginal lines. Referring to the last named peculiarity of structure, Smith notices Ehrenberg's ideal transverse section of the frustule, "which represents the ridges as springing from the surface of a convex valve, having between them a depression which corresponds with the ordinary median line of the Naviculæ," and adds, "I am unable to confirm this description."—B.D., Vol. i., p. 45. Grunow, however, asserts that "each valve has three keels; the two submarginal ones springing out so far in one aspect as to stand on the valves at right angles with the margin. In the aspect of the entire frustule as seen from the side, the submarginal keels appear, and the median line forms the contour of the valves."—Verhand. der K. K. Zool. Bot. Gesel. Band xii., 1862, p. 467.

Amphipleura pellucida, (Kütz.) Fresh water.

Valves narrow, lanceolate; striæ obscure. (Pl. 29, fig. 8.)

Kütz. Bac., p. 103, T. iii., fig. 52, T. xxx., fig. 84. In neither of these figures is the peculiar form of the end nodules noticed. Wm. Sm., B. D., Vol. i., p. 45, Pl. xv., fig. 127. Here the valve is represented without the median line, and having a longitudinal row of moniliform puncta interposed between the margin and the submarginal keels: the latter I have never been able to detect. Ralfs, in Pritch., p. 783, Pl. iv., fig. 30, Pl. ix., fig. 140, and Pl. xiii., fig. 1. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, p. 468. Heiberg, De Danske Diat., p. 117. Rab. Fl. Eur., sect. 1, p. 143.

Limestone quarry near Mullingar, Co. Westmeath. Marl-pit, Inch, near Gorey, Co. Wexford. Feighcullen, Co. Kildare.

Amphipleura danica, (Kütz.) Marine.

Similar to the preceding in all respects, save that it is shorter and relatively broader.

Kütz. Bac., p. 103, T. xxx., fig. 38. Ralfs, in Pritch., p. 783. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii., 1862, pp. 468 and 470. Grunow is uncertain as to whether the median line has the elongated end nodules; but of this there is no doubt, my specimens invariably exhibiting the same: and he seems to regard the species as identical with Amphipleura rigida, Kütz, this latter being in fact the same as Amphipleura sigmoidea, Wm. Sm., and belonging not to the genus Amphipleura, but to Nitzschia.

Stomachs of Ascidians, Co. Clare.

Family VIII. NAVICULEÆ, Kütz.

Frustules oblong, having both valves furnished with a median line, central, and two terminal nodules.

In this group I include all those forms with symmetrical frustules, more or less oblong elliptical in their outline, and having both valves furnished with a median line, also with a central and two end nodules; quite irrespective of their mode of growth, in tubes, stipitate, or free, filamentous or simple. So limited, Gomphonema, and Cocconeis, included by Heiberg as Naviculeæ cuneatæ, are necessarily excluded on account of the unsymmetrical structure of their valves; while the species which normally occur, surrounded by a more or less amorphous mass of gelatinous investment, as Dickiea and Mastogloia, as well as those which grow in tubes more or less composite, as Berkleya, Colletonema, Schizonema; Doryphora, which is stipitate, Diadesmis, which is filamentous, as well as the genera which grow free, and without any investment, are included, because their frustules, however varying in minor details, ever exhibit the same general features. If Kützing, Smith and others, assigning too much value to the secondary modes of growth, have widely separated genera which are intimately related by a common structure, Heiberg on the other hand regards as of little or no significance these peculiarities of growth, which, although subordinate to the general structure of the frustules, should not be overlooked. These differences, as they occur normally, are doubtless assignable to some peculiarity in the structure of the plants which regularly develop them. They therefore demand the careful attention of the students of nature, and, as I think, ought to be marked by a special designation.

(a). *Chlamydiæ—Frustules enveloped in a more or less definite frond.*

Genus I. MASTOGLOIA, Wm. Smith and Thwaites.

Mucous frond in such species, as have been observed *in situ*, papillate, the frustules imbedded in the top of the papillæ; frustules furnished with narrow-marginal silicious plates interposed between the valve and the connecting band.

Kützing, (Bac. p. 92, T. xxx., fig. 37,) describes a form under the name of Navicula meleagris, which evidently belongs to this genus. Thwaites, Ann. Nat. Hist., March, 1848, gives a description of another form belonging to this genus, under the name of Dickiea danseii, but when the characteristic difference in the form of the mucous investment was pointed out by Smith, (B. D., vol. ii., p. 64), he established the genus Mastogloia to receive a new form discovered by himself, as well as some others that had meanwhile been brought under his notice. The genus therefore may in some measure be attributed to Smith; the more so because he first seems to have noticed and described one of the most important features in the structure of the frustule. He says, "The frustules of Mastogloia are notably distinct from those of any other genera of the tribe having the annulate structure, described under the genus Rhabdonema with the conspicuous canaliculi of a Surirella. In the present case, the canaliculi which take the form of loculi are, however, formed differently from those of Surirella, not being connected with the valve, but with the annulus, which projects as a septum into the body of the frustule." And again, "Normally the annular septum extends only partially across the interior of the frustule, but occasionally the loculi are seen to reach nearly as far as the median line of the valve." —B. D., Vol. ii., p. 63. In reference to this description, Grunow remarks, "I have been unable to convince myself of the correctness of Smith's supposition, that the costæ which according to him form diaphragms are attached to the connecting membrane. After numerous observations, I find they are quite analogous to the costæ of other Diatoms, and are an inner layer of the silicious plate which in this instance separates itself from the outer layer more easily than in other Diatoms."—Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 574. Heiberg's views on the subject of dispute are thus expressed: "Smith on the contrary took an erroneous view of the genus as such, inasmuch as he regarded the inner layer of the valves on which the characteristic costæ are situated as an annulus or diaphragm of the same structure as that which we find in the Striatelleæ: also he considered the costæ to be canaliculi, which does not correspond with the actual facts of the case. Grunow has the merit of having been the first to point out the error of the opinion of Smith above referred to."—De Danske Diat., p. 92. Whether the plate bearing the loculi is more intimately associated with the connecting membrane, as Smith thought, or with the valve itself, as Grunow and Heiberg are of opinion it is, this is certain, so far as my observation extends, that, as Grunow remarks, the plate seems to attach itself more frequently to the valve than to the connecting membrane; but as the valves frequently occur without the plate, and the plate is often found detached, I am disposed to consider it not so much an inner layer of the silicious epiderm as a separate formation, and much more intimately related to the diaphragms of the Striatelleæ than to the inner layer which bears the costæ in the Epithemiæ. Smith describes the loculi as opening by foramina along the line of suture, a statement which Ralfs repeats. I have however failed to notice any such openings, the plate having ever appeared to be perfectly solid. Inasmuch as Thwaites considered the occurrence of the frustules in gelatinous cushions the distinctive character of the genus Mastogloia, and other distinguished writers have entertained the same opinion, Grunow's remark on the subject is deserving of attention: "Whether the species of the genus Mastogloia occur invariably in a gelatinous investment, is a matter concerning which I am very doubtful, as in a fresh collection I observed Mastogloia Smithii free, while I found no specimens in a gelatinous cushion"—Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 575. However this may be, the occurrence of the plate with loculi in the perfect frustule is a mark of distinction which identifies the genus. Further, it was considered by Grunow, that the occurrence of the inner layer with its costate striation, so different from the sculpture of the valve, constitutes a strong bond of affinity between Mastogloia and Cocconeis. If, however, the opinion I have expressed as to the distinctness of the plate from the valve be correct, this resemblance fails, and in the general details of structure the two genera are widely distinct. The process of reproduction in this genus has been observed by Lüders: according to his observations, two mother cells produce two auxospores. Pfitzer, Untersuchungen über Bau und Entwicklung der Bacillariaceen, p. 74, remarks, "that in this feature the genus corresponds with the Naviculeæ, and not with the Cocconeideæ in which Grunow placed it; for the latter, out of two mother cells, develop but a single auxospore."

Mastogloia lanceolata, (Thwaites.) Marine or brackish water.

Valves lanceolate; marginal plate wide at middle, and gradually tapering to the ends; loculi narrow, and numerous; median line slightly undulate; strongly marked at the central nodule, and greatly attenuated towards the ends; striæ linear, fine; slightly radiate; not quite reaching the median line, but terminated by two strongly developed sulci, which bend in slightly towards the central nodule at either end, leaving a narrow lanceolate space about the median line free from striæ.

Smith and Grunow, the former doubtfully, regard this form as identical with Navicula meleagris, Kütz. Bac., p. 92, T. xxx., fig. 37. Rabenhorst, however, regards Kützing's form as distinct from the present; and in this I am disposed to agree with him, as I have seen specimens exactly corresponding with that of Kützing, and as I think quite distinct from Mastogloia lanceolata.

Wm. Sm., B. D., Vol. ii., p. 64, Pl. liv., fig. 340. The figure and description are correct, as far as they go, but neither the longitudinal sulci about the median line, nor the striæ are described. Ralfs, in Pritch., p. 924. Grunow, Verhand. der Zool. Bot. Gesel., Band x. 1860, p. 576. Heiberg, De Danske Diat., p. 94. Rab. Fl. Eur., sect. 1, p. 261. Cleve, Om Svenska och Norska Diat., p. 230.

Tacumshane, Co. Wexford. Lough Gill, Co. Kerry. Salt marsh, Kilcool, Co. Wicklow. Salt marsh near the town of Galway. Dollymount Strand, Co. Dublin.

Mastogloia convergens, N. S. Marine or brackish water.

Valve broadly elliptical; length ·0018; breadth ·0008; rounded at ends; median line straight, strongly marked, and of equal breadth throughout; central nodule small and round: marginal plates broad in the middle, gradually attenuated towards the ends, at some distance from which they bend outwards; the space between the plates is broadly lanceolate at either end, and narrower in the middle, where the boundary line curves very gently towards the margin; loculi broader than in the last; striæ fine, linear, convergent in the middle of the valve, where they are stronger and farther apart, and for the remainder gently radiate. (Pl. 29, fig. 9.)

On first view, this form might readily be confounded with the preceding; but the more carefully it is examined, the more apparent are its distinctive characteristics. In its outline, it is broader for the length than Mastogloia lanceolata; its ends are broader, and more round. In the latter, the loculi are more numerous, shorter in the middle, and gradually diminishing towards the ends; in the present case, the loculi are wider in the middle, and suddenly become attenuated towards the ends. The longitudinal sulci near the median line, so marked a feature of M. lanceolata, are wanting in this. In M. lanceolata, the striæ are uniformly radiate; in M. convergens, they are convergent in the middle, and for the rest more decidedly radiate than in the other.

Salt marsh near the town of Galway. Lough Gill, Co. Kerry, accessible to the tide.

Mastogloia closeii, N. S. Marine or brackish water.

Valve somewhat rhomboid; length ·0018; breadth ·0008; ends narrow, lanceolate; median line straight; central nodule very small; marginal plates wide in the middle for a short space, and rapidly attenuated long before reaching the ends; loculi generally four in number, two large in the middle, and one at either side narrow, attenuated; space between the inner margin of plates wide, shaped somewhat like an hour-glass, with pointed ends; striæ fine, linear, radiate, reaching the median line. (Pl. 29, fig. 10.)

Found first in a gathering by Rev. Maxwell H. Close, from rock pools in the bay called Lough Kay, between Cahirciveen and Doulus Head, Co. Kerry. Lough Gill, Co. Kerry. Sea-weeds, Giants' Causeway, Co. Antrim.

Mastogloia portierana, (Grunow.) Marine.

Valves narrow, lanceolate; slightly produced at the apex; marginal plates narrow; gradually attenuated towards the ends; loculi numerous; striæ very obscure. (Pl. 29, fig. 11.)

This form is very similar in some respects to large specimens of Mastogloia lanceolata, but differs in many details; it is longer, and proportionately narrower; the sulci at either side of median line in the case of M. lanceolata are absent in this; the apices, too, are slightly produced, and the striæ much finer than in that species. Grunow states that, with an amplifying power of 400 times, the striæ are scarcely noticeable; but in the several specimens examined by me with a one-eighth objective and deep eye-piece, the striæ could not be discovered. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band xii.; 1863, p. 157, T. iv., fig. 13. Rab. Fl. Eur., sect. 1, p. 236.

From stomachs of Ascidians, Roundstone Bay, Co. Galway.

Mastogloia danseii, (Thwaites.) Marine or brackish water.

Valve linear, elliptical; broadly rounded at ends; striæ reaching the median line, but slightly shortened around the central nodule; radiate, formed of close puncta; marginal plates on inner margin straight till near the ends, where they are suddenly attenuated; loculi numerous, parallel; space between the plates narrow, and slightly expanded at the ends.

Wm. Sm., B. D., Vol. ii., p. 64, Supp. Pl. lxii., fig. 388. Ralfs, in Pritch., p. 924, Pl. xv., fig. 30. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 576. Rab. Fl. Eur., sect. 1, p. 261.—Dickiea danseii, Thwaites, Ann. Nat. Hist., March, 1848, p. 171. Smith seems to think that this species hardly differs from Mastogloia lanceolata, but a careful consideration of the two forms will, I think, prove that in all the details they are essentially different.

Tacumshane, Co. Wexford. Lough Foyle, Co. Londonderry. Larne, Co. Antrim. Salt marsh, Kilcool, Co. Wicklow.

Mastogloia apiculata, (Wm. Sm.) Marine.

Valves broadly elliptical; slightly produced at the ends; median line fine, with two sulci, one at either side, and very close to it; parallel for greater part of length, and converging towards the ends; central nodule small; marginal plates narrow, gradually attenuated towards the ends, where they suddenly decrease in breadth; loculi numerous; space between the inner margins broadly elliptical, and slightly expanded at the ends; striæ fine, closely punctate, slightly radiate.

Wm. Sm., B. D. Vol. ii., p. 65. Supp. Pl. lxii., fig. 387. Ralfs, in Pritch., p. 925. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 577, T. vii., fig. 9. Rab. Fl. Eur., sect. 1, p. 262.

Dollymount Strand, Co. Dublin. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Mastogloia smithii, (Thwaites.) Fresh or brackish water.

Valves elliptical; frequently produced at the ends; marginal plates relatively broad; attenuated at the ends; space included between the inner margins narrow; slightly expanded at the ends; striæ fine, linear; slightly radiate. (Pl. 29, fig. 12.)

This form varies greatly in size and shape, as well as in the habitat. It seems essentially a fresh water form, for I have found it frequently in localities far remote from marine influences; and also in places where, so far as I could judge, there was no likelihood of mixture of fresh water with the salt. Under the circumstances, I was anxious to submit the forms to the most rigid examination, but could detect no specific difference between them. Grunow observes that, in the specimen that came under his notice, there was even a tolerably wide transversely expanded central nodule, which he considers should be established as the characteristic distinction between this species and Mastogloia lanceolata. I may mention that this feature, though frequently noticeable, is not of universal occurrence.

Wm. Sm., B.D., Vol. ii., p. 65, Pl. liv., fig. 341. Ralfs, in Pritch., p. 925. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 575, T. vii., fig. 11. Rab. Fl. Eur., sect. 1, p. 261. Cleve, Om Svenska och Norska Diat., p. 230.

Tacumshane, Co. Wexford. Lough Gill, Co. Kerry. Kilcool, Co. Wicklow. Newtownlimavady, Co. Derry. In all which gatherings there was a mixture of fresh and brackish forms. Tide pool, Greystones, Co. Wicklow, where the forms were mostly marine. Lough Corrib, Co. Galway, wholly free from marine influence.

Var. capitata, (Wm. Sm.) Fresh water.

Agreeing with the typical form, only that the produced ends are capitate; the striæ, also, which are similarly arranged, may easily be resolved into minute dots.

Wm. Sm., B. D., Vol. ii., p. 65, Pl. liv., fig. 341 B. In all probability, this is identical with the form described by Greville, Q. J. M. S., October, 1862, p. 235, Pl. x., fig. 11; although that author remarks that in his form the striæ were much more obscure than in the form figured by Smith as above.

Lough Corrib, Co. Galway, mixed with the typical form.

Mastogloia grevillii, (Wm. Sm.) Fresh water.

Valve linear; cuneate at the obtuse extremities; marginal plate nearly linear on the inner margin, suddenly attenuated towards the ends; loculi numerous; striæ fine, linear, radiate, shortened at the central nodule, so as to give a stauro-form appearance to the valve.

Wm. Sm. B. D. Vol. ii., p. 64, Supp. Pl. lxii, fig. 389. Ralfs, in Pritch., p. 925. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 575. Heiberg, De Danske Diat., p. 94. Rab. Fl. Eur., sect. 1, p. 260.

Kilcool, Co. Wicklow. Lough Neagh, Co. Antrim. Ballyshannon, Co. Donegal. Carrickhugh, Co. Derry.

Mastogloia costata, N. S. Fresh water.

Valve linear; cuneate at ends; length ·0013, breadth ·0005; marginal plates broad, on inner margin perfectly linear till near the ends, where they very slightly expand, in shape of a spear head; loculi numerous; striæ strongly costate, converging in the middle, and for the rest radiate; shortened at the central nodule. (Pl. 29, fig. 13.)

In shape and size, this form is so like Mastogloia grevillii that it might easily be confounded with it; but, however, on closer investigation it will appear quite distinct. In M. grevillii, the fine linear striæ can by proper focusing be easily seen along with the loculi of the marginal plate. In the present species, either from the convexity of the valve, or the coarseness and closeness of the costate striæ, or perhaps owing to both these circumstances, the plates are not easily detected, except at the inner margin, where their boundary may be detected by the clear intervening space into which the ends of the strong costæ are seen to project.

On a moist rock, Ballyshannon, Co. Donegal.

Genus II. Dickieia, Berkeley.

Frond flat, leaf-like; unbranched; frustules scattered without regular arrangement.

Smith attributes this genus to Ralfs; but Ralfs himself ascribes it to Berkeley. It is adopted by Kützing, Smith, Grunow, and Rabenhorst, but Heiberg rejects it as being unnecessary, the forms being, as he thinks, ranged properly with the Naviculæ.

Dickieia ulvoides, (Berk.), Marine.

Gelatinous frond, more or less perfectly ovate; entire, and having a distinct pedicel; valves linear, elliptical; central nodule transversely dilated; striæ fine, parallel. (Pl. 29, fig. 14.)

Berkeley and Ralfs, Ann. Nat. Hist., Series 1., Vol. xiv., Pl. ix., Kütz. Bac., p. 119. Wm. Sm., B. D., Vol. ii., p. 66, Pl. liv., fig. 342. Ralfs, in Pritch., p. 925, Pl. xv., fig. 31. Rab. Fl. Eur., sect. 1, p. 264.

Greystones, Co. Wicklow.

Dickieia pinnata, (Ralfs), Marine.

Frond lasciniated; valves narrow, elliptical; striæ fine, parallel; nodule small, round.

Ralfs. Ann. Nat. Hist., 2nd Series, Vol. viii., Pl. v., fig. 6. Ralfs, in Pritch., p. 925. Wm. Sm., B. D. Vol. ii., p. 66, Pl. liv., fig. 343. Rab. Fl. Eur., sect. 1, p. 264.

On piles of the wooden bridge, Dollymount strand; Wooden piles on strand, Clontarf; Sea-weeds, Malahide; Ireland's eye; Rock-pools, Ballybrack, Co. Dublin: in the last named locality it occurs in greatest abundance. Larne, Co. Antrim.

Genus III. Colletonema, De Brèb.

Gelatinous frond filiform, simple or sparingly divided at the ends.

The first known forms of this genus were discovered by Thwaites, and published by him in Ann. Hist., March, 1848, under the generic name of Schizonema. De Brèbisson subsequently separated these forms from Schizonema, and instituted the present genus for their reception; the distinguishing characters being their fresh water habitat, and the simple tubular frond. Whatever value may attach to the latter peculiarity, the former is utterly untenable as a generic distinction. Smith alleges that in this genus the frustules are more firmly silicious than in Schizonema, a statement I cannot corroborate; but even though it admitted of no doubt, this fact could scarcely be regarded as a sufficient generic distinction. Rabenhorst, Süssw. Diat., p. 51, who himself observed none of the species, adopts the genus, characterising it by the fact of the frustules occurring in rows within a structureless gelatinous investment. Ralfs adopts Smith's definition, but doubts "if any of the above characters sufficiently distinguish Colletonema from the allied genera," in Pritch., p. 926. Grunow's observations on the genus are noteworthy; he says: "The genus

Colletonema is in a twofold aspect uncertainly founded. On the one hand, it can scarcely be rightly separated from Schizonema, in which small forms occur in simple sheaths, and on the other hand its separation from Navicula is very uncertain. It appears to me that many species of Naviculæ may, under certain conditions, occur, as well in gelatinous masses as inclosed in gelatinous tubes, and two of the forms which I have with some hesitation placed in this genus appear to me to confirm this impression." Farther on, in his observations on Colletonema neglectum, he remarks: "I once observed this species in an unused mill-stream in which Navicula gracilis occurred in uncommon abundance, and for the most part certainly in a free state; very frequently also were found gelatinous tubes filled with perfect frustules of Navicula gracilis, just as Smith has described it, and also very unfrequently bands consisting of double rows of the same Navicula without any sheaths; nor could I by the most careful examination discriminate between these forms and those of Navicula gracilis from other localities, where no gelatinous tubes were discovered."—Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, pp. 570, 571. These observations coincide with the supposition of Wm. Smith, that "Pinnularia radiosa may be merely a free state of Colletonema neglectum and Navicula crassinervia, the same condition of Colletonema vulgare." B. D., Vol. ii., p. 69. I take the opportunity of remarking that, in a gathering made by me from Lough Aron, on the summit of the Slieveanicran mountain, Co. Antrim, in the summer of 1872, Navicula rhomboides occurred in great abundance; some of the forms were free and active, others were inclosed in gelatinous tubes, invariably arranged in single files, and by no means uncommonly the frustules were seen in long files, attached apparently one to another by the ends, without the slightest appearance of tubes, just as in Grunow's case of Navicula gracilis. Rabenhorst restores the species of this genus to Schizonema; and Heiberg, rejecting the generic distinction founded on the gelatinous tubes in which the frustules are invested, unites them with Navicula.

Reproduction has been observed by Thwaites in the case of Colletonema subcoherens; he says: "The Sporangia of this species are produced by the conjugation of a pair of frustules outside the filaments; but sporangial frustules are frequently found in a filament intermixed with ordinary frustules, from which they differ only in size."—Ann. Nat. Hist., March, 1848. Pfitzer superadds, that "two cells produce two auxospores."—Untersuchungen, p. 73.

Colletonema eximium, (Thwaites), Fresh water.

Frond filiform, frustules arranged in one or more rows; valve sigmoid, striæ fine, parallel.

Rab. Süssw. Diat., p. 51. Wm. Sm., B. D., Vol. ii., p. 69, Pl. lvi., fig. 350. Ralfs, in Pritch., p. 926, Pl. viii., fig. 43. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 573, who remarks, regarding this species: "it must either be transferred to Pleurosigma, or a new genus established to receive it."—Schizonema eximium, Thwaites, Ann. Nat. Hist., March, 1848. Rab. Fl. Eur., sect. 1, p. 266.—Gloionema sigmoides, Ehr. Abh., 1845, p. 78.—Encyonema sigmoides, Kütz. Alg., p. 62.—Endosigma eximium, De Brèb.

Tacumshane, Co. Wexford. Near Railway station, Newtownlimavady, Co. Derry.

Colletonema vulgare, (Thwaites). Fresh water.
Frond occasionally divided; frustules elliptical, lanceolate, striæ very fine.
In Smith's figure the striæ are described as radiate, but I have never been able to resolve them.
Wm. Sm., B. D., Vol. ii., p. 70, Pl. lvi., fig. 351. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 572. Ralfs, in Pritch., p. 926.—Schizonema vulgare, Thwaites, Ann. Nat., Hist., 2nd Series, Vol. i., p. 10, Pl. xii., fig. H. Rab. Fl. Eur., sect. 1, p. 265.—Navicula vulgaris, Heiberg, De Danske Diat., p. 83.

Carrickmacreilly Mountain near Glanealy, Wicklow: the species is very uncommon.

Colletonema neglectum, (Thwaites.) Fresh water.
Frond slightly divided; frustules closely packed; elliptical, lanceolate; extremities obtuse; striæ finely costate, radiate. (Pl. 29, fig. 15.)
Wm. Sm., B. D., Vol. ii., p. 70, Pl. lvi., fig. 352. Ralfs, in Pritch., p. 926. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., p. 571.—Schizonema neglectum, Thwaites, Ann. Nat. Hist., 2nd Series, Vol. i. p. 11, Pl. xii., J. Rab. Fl. Eur., sect. 1, p. 265.

Genus IV. BERKELEYA, Greville.

Frond branched, the branches springing from a basal tubercle.

Most authors adopt this genus, but Heiberg rejects it as unnecessary, and includes the species under Navicula.

Berkeleya fragilis, (Greville.) Marine.
Frustules closely packed in the tubes. Valves elliptical, lanceolate, broadly rounded at the ends. Striæ obscure. (Pl. 29, fig. 16.)
Grev. Scot. Crypt. Flora. tab. 294. Do. Brit. Flora. p. 416. Ralfs, Ann. Nat. Hist., 1st Series, Vol. xvi., Pl. iii., fig. 2. Do., in Pritch., p. 926. Kütz. Bac., p. 109. Wm. Sm., B.D., Vol. ii., p. 67, Pl. liv., fig. 344. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 512. Rab. Fl. Eur., sect. 1, p. 264.—Navicula fragilis, Heiberg, De Danske Diat., p. 84. Bangia micans, Lyngbye, Tent. Hydro-

phyt., p. 84. This last synonym is given on the authority of Heiberg, who had the opportunity of inspecting authentic specimens.

Cork Harbour, Wm. Smith. Rock-pool, Salt Hill, Co. Dublin. Coast of Galway, from collections by M'Calla, in the Herbarium, Trinity College, Dublin.

Genus V. Schizonema, Agardh.

Frond usually much divided. Frustules arranged in one or more files within the gelatinous tubes which constitute the frond.

Smith remarks justly that "the fronds in this extensive genus were amongst the earliest Diatomaceous organisms recognised by naturalists, and have been the perplexity of all subsequent observers." Nor is this to be wondered at, when the difficulties attendant on their examination are taken into consideration. The frustules enveloped in the fronds are generally minute, so that even though they were free it would be no easy matter to examine them satisfactorily, and the difficulty is much enhanced by the intervention of the fronds as well as by the manner in which the frustules are packed within them. Kützing attempted to arrange the species on the basis of the characters of the fronds, but with how little success the student will be convinced who endeavours to make himself master of the subject by the aid of his minute descriptions, and of his very indefinite figures. Heiberg falls into a mistake the very opposite to that of Kützing—discarding from consideration not only the characters of the fronds in the various species, but regarding the fact of the frustules being normally incased within fronds as an unreliable generic distinction, and so he ranks the species under the genus Navicula. De Brèbisson had observed that "the greater part of the species needed reconsideration, and to be studied with regard to the character of the frustules." and Smith, with his characteristic sagacity, taking this hint, at the same time not overlooking any reliable character exhibited by the fronds, dispelled the confusion which had hitherto existed, and reduced the species into an order, which seems, all the circumstances considered, to admit of little improvement.

As to the mode of reproducing the sporangia in the genus, opinions differ, as the following extract from Pfitzer will sufficiently show:—"In Schizonema Grevillii, according to Smith, a single mother-cell produces a single auxospore, while according to Lüders this occurs but seldom, namely, when one auxospore becomes defunct; usually, on the contrary, two cells co-operate, and form two auxospores. The development of the latter occurs outside the tubes in a large and fine mucous investment. The mode of proceeding, according to Lüders, is that each mother-cell divides itself, and the halves unite in pairs. However, in other forms in which, according to Lüders, a similar state of things occurs, I have not found this view confirmed. So that probably Schizonema does not differ in this respect from the rest of the Naviculæ."—Untersuchungen über Bau und Entwicklung der Bacillariaceen, p. 73.

(†) *Frustules with parallel striæ.*

Schizonema crucigerum, (Wm. Sm.) Marine.

"Frond filiform; filaments implicate below, free above, much divided. Frustules crowded. Valves with a distinct stauros, lanceolate, acute" (Wm. Smith) on side view; on front view wider in the middle than at ends. Striæ distinct, close, linear. (Pl. 29, fig. 17.)

In Smith's figure, the striæ are described as slightly radiate, but in my specimens, I find them parallel.

Wm. Sm., B. D., Vol. ii., p. 74., Pl. lvi., fig. 354, and Pl. lvii., fig. 356. Ralfs, in Pritch., p. 928. Rab. Fl. Eur. sect. 1, p. 266. —Stauroneis crucigera, Heiberg, De Danske Diat., p. 88.

Tacumshane, Co. Wexford. Malahide, Portmarnock, Salt-hill, Co. Dublin. Rostrevor, Co. Down. Lough Gill, Co. Kerry.

Schizonema smithii, (Agardh.) Marine.

"Frond, filiform, robust, simple below, much divided, fasciculated and fastigiate above. Frustules in numerous closely set files. Valves elliptico-lanceolate, acute."—Wm. Smith. To which I would add, striæ, obvious, extending to median line. Front view of frustule regularly quadrangular. (Pl. 29, fig. 18.)

Agardh. Conspectus, p. 18. Kütz. Bac., p. 114, T. xxvii., fig. 5. Wm. Sm., B. D., Vol. ii., p. 75, Pl. lvii., fig. 362. Rab. Fl. Eur., sect. 1, p. 269.—Micromega Smithii, Ralfs, in Pritch., p. 930.

Howth, Salt Hill, Malahide, Co. Dublin. Sea coast, Co. Antrim.

Schizonema divergens, (Wm. Sm.) Marine.

"Frond, simple below, sparingly divided, or by cohesion irregularly submembranous above; ultimate ramuli short, obtuse."—Wm. Smith. Valve, shorter and wider than the last, and more rounded at the ends. Striæ fine, linear, reaching the median line.

Wm. Sm., B. D., Vol. ii., p. 76, Pl. lvii., fig. 363. Rab. Fl. Eur. sect. 1, p. 269.—Micromega divergens, Ralfs, in Pritch., p. 931.

Besides the locality named by Wm. Smith, Larne Lough, where it was collected by Dr. Dickie, this species has been gathered by myself at Malahide and Salt-hill, Co. Dublin; and by Dr. David Moore, at Carrickfergus and Carnlough Bay, Co. Antrim.

Schizonema mucosum, (Kütz.) Marine.

"Frond filiform, gelatinous, simple below, by cohesion sub-membranous above. Margin irregularly ramulous. Frustules in files, few, sub-distant. Valve elliptical, delicately striate." Wm. Smith. Not unlike the last, except that it is more delicately striate, shorter, broader, and more rounded at ends.

Kütz. Bac., p. 115, T. xxvi., fig. 9. Wm. Sm., B. D., Vol. ii., p. 75, Pl. lvii., fig. 360. Rab. Fl. Eur., sect. 1, p. 268.—Micromega mucosum, Ralfs, in Pritch., p. 933.

With seaweeds, Galway, Dr. David Moore. Malahide, Howth, Co. Dublin.

Schizonema ramosissimum, (Agardh.) Marine.

"Frond filiform, much divided from the base, and irregularly sub-membranous by cohesion above. Ramuli short, obtuse. Frustules numerous, in closely packed files. Valves elliptico-lanceolate, acute."—Wm. Smith. Striæ fine, linear.

Agardh. Syst., p. 11. Harvey's Manual, p. 210, who, according to Smith, had the opportunity of inspecting authentic specimens. Wm. Sm., B. D., Vol. ii., p. 78, Pl. lix., fig. 369. Rab. Fl. Eur. p. 272.—Micromega ramosissimum, Agardh. Consp., p. 22. Ralfs, in Pritch., p. 934.

Near Larne, Carnlough, Co. Antrim, collected by Dr. David Moore.

(††). *Frustules having radiate striæ.*

Schizonema grevillii, (Agardh.) Marine.

"Frond filiform, much divided from the base, Ultimate ramuli acute, larger divisions with several files; ultimate ramuli with a single file of frustules. Valve lanceolate."—Wm. Smith. Striæ fine, gently radiate. On the front view, frustules are very wide, quadrangular. The side view appears nearly as far as the median line. The central nodule thus seen is depressed. The connecting band exhibits longitudinal lines. (Pl. 29, fig. 19.)

Agardh. Conspect., p. 19. Kütz. Bac., p. 114, T. xxvi., fig. 4., T. v., fig. 1. Wm. Sm., B. D., Vol. ii., p. 77, Pl. lviii., fig. 364. Ralfs, in Pritch., p. 928. Rab. Fl. Eur., sect. 1, p. 267.—Schizonema quadripunctatum, Harvey's Manual, p. 214.

Larne, Carrickfergus, Co. Antrim, collected by Dr. David Moore. Malahide, Merrion, Co. Dublin. River Nannywater, near Laytown, Co. Meath.

Schizonema helmintosum, (Chauvin.) Marine.

"Frond filiform, or by cohesion irregularly sub-membranous; much and irregularly divided; ultimate divisions short, abrupt."—Wm. Smith. Frustules linear, elliptical, sometimes sharp, sometimes more rounded at the ends. Striæ fine, obscurely punctate, convergent about the central nodule, and for a considerable distance from it, towards the ends straight and radiate.

Agardh. Conspect., p. 20. Grev. Brit. Flora, p. 412. Harvey's Manual, p. 210. Kütz. Bac., p. 114, T. xxvii., fig. 6. Wm. Sm., B. D., Vol. ii., p. 74, Pl. lvi., fig. 355. Rab. Fl. Eur., sect. 1, p. 268.—Micromega helmintosum, Ralfs, in Pritch., p. 830.

Howth, Malahide, Co. Dublin. Carnlough Bay, collected by Dr. David Moore.

Schizonema comoides, (Agardh.) Marine.

"Frond filiform, simple below, much divided and fasciculated above. Frustules crowded."—Wm. Smith. Frustules small, length about ·0010, somewhat rhombic on front view, rounded slightly at the ends. Striæ strong and distant at centre, finer and closer towards the end; on front view linear, in outline rounded at ends.

Agardh. Conspect., p. 19. Harvey's Manual, p. 213. Wm. Sm., B. D., Vol. ii., p. 75, Pl. lvii., fig. 358. Rab. Fl. Eur., sect. i., p. 268.—Schizonema araneosum, Kütz. Bac., p. 113, T. xxiv., fig. 2, T. xxv., fig. ix.—Micromega comoides, Ralfs, in Pritch., p. 934.

Carnlough Bay, Co. Antrim, collected by Dr. David Moore. Howth, Malahide, Co. Dublin.

Schizonema parasiticum, (Harvey.) Marine.

"Frond capillary, branched, filaments slightly cohering above. Ramuli short, patent. Mucus often rugose. Frustules crowded in files, more or less distant. Valves elliptico-lanceolate, acute. Length of frond 5″; length of frustule ·0011; breadth of valve ·0002."—Wm. Smith. Striæ extremely fine. Frustule on front view quadrangular.

Harvey's Manual, p. 213. Wm. Sm. B. D., Vol. ii., p. 79, Pl. lix., fig. 37. Rab. Fl. Eur., p. 273.—Micromega parasiticum, Kütz. Bac., p. 116, T. xxvii., fig. 2. Ralfs, in Pritch., p. 932.

Malahide, Salt Hill, Co. Dublin.

Schizonema laciniatum, (Harvey.) Marine.

"Frond filiform, much branched, filaments often adhering into rope-like tufts. Ramuli very long. Frustules numerous, crowded in irregular files. Valves elliptical, somewhat acute. Length of frustule ·0018; breadth of valve ·00035."—Wm. Smith. Valves striate; striæ punctate, gently radiate. On front view frustules broader at middle than at ends, ends rounded off; side view coming largely into sight when observed in front, the inner margins nearly meeting the connecting membrane, and at the ends receding therefrom.

On careful inspection of authentic specimens of Schizonema implicatum (Harvey), I find the frustules on side and front view so like one another in all respects that, judging from the frustules alone, I am disposed to consider that it is not distinct from the present; nor does the general appearance of the fronds differ so much as to be irreconcilable with this impression.

Harvey's Manual, p. 210. Wm. Sm., B. D., Vol ii., p. 79, Pl. lix., fig. 370. Rab. Fl. Eur., sect. i., p. 273.—Schizonema scoparium, Kütz. Bac., p. 114, T. xxvii., fig. 1.—Micromega laciniatum, Ralfs, in Pritch., p. 932.

Carrickfergus to Antrim, collected by Dr. David Moore. Galway, collected by M'Calla.

Schizonema gracillimum, (Wm. Sm.) Marine.

"Frond capillary, simple below; sparingly branched and sub-membranous towards the apices. Frustules crowded in irregular files. Valves elliptico-lanceolate. Length of frustule .0009, breadth of valve ·00015."—Wm. Smith. Striæ linear, very slightly radiate. Frustule on front view narrow, quadrangular. So far as the frustules are concerned, in outline and general appearance the species differs little from Schizonema parasiticum. The striæ may be a little coarser and the valve somewhat narrower.

Wm. Smith, B. D., Vol. ii., p. 79, Pl. lix., fig. 372.—Micromega gracillimum, Ralfs, in Pritch., p. 934.

Nannywater, Laytown, Co. Meath.

(†††). *Frustules without striæ.*

Schizonema obtusum, (Grev.) Marine.

"Frond filiform, sparingly branched, apices abrupt. Frustules exceedingly numerous, in irregular files; valves elliptical. Length of frond 1"; length of frustule ·0011; breadth of valve ·00025." Wm. Smith. To which should be added that the valves are rounded at the ends. (Pl. 29, fig. 20.)

Greville, Brit. Fl., p. 413. Harvey's Manual, p. 209. Rab. Fl. Eur., sect. 1, p. 272.—Micromega obtusum, Ralfs, in Pritch., p. 931.

Near Dunluce Castle, Portballintrae, Co. Antrim, collected by Dr. David Moore. Merrion, Malahide, Co. Dublin. Galway.

Schizonema dilwynii, (Agardh.) Marine.

"Frond capillary throughout, sparingly branched, tenacious; apices acute. Frustules exceedingly crowded towards the apices, scattered and remote in the older portions. Valves lanceolate, acute. Length of frond 2" to 5", or upwards; length of frustule ·0008; breadth of valve ·0002." Wm. Smith. So far as the frustules are concerned there is but little difference between this and the preceding species; the only difference being that while in the former case the valve is rounded at the ends, in the present case they are acute. I have sometimes found both species in the one gathering.

Agardh. Syst., p. 10. Id. Consp., p. 20. Grev. Brit. Fl., p. 412. Harvey's Manual, p. 212. Kütz., Bac., p. 118, T. xxvi., fig. 3. Wm. Sm., B. D., Vol. ii., p. 77, Pl. lviii., fig. 366. Ralfs, in Pritch., p. 928. Rab., Fl. Eur., sect. 1, p. 272.

Rathlin Island, Carrickfergus, Carnlough Bay, Co. Antrim—all collected by Dr. David Moore. River Nannywater, Laytown, Co. Meath. Merrion, Co. Dublin.

(b). *Achlamydiæ. Frustules without a gelatinous investment.*

Genus VI. DIADESMIS, Kütz.

Frustules united in a filament.

Diadesmis williamsonii, (Wm. Sm.) Marine.

On front view margins of frustules undulate, and exhibiting the striation of the valve; on side view, valve linear, acuminate at the ends. Striæ moniliform. (Pl. 29, fig. 21.)

This form was first partially described by Wm. Smith, B. D., Vol. ii., p. 14, Pl. xxxiii., fig. 287, who, having seen only the front view so accurately figured by him, doubtfully referred it to the genus Himantidium. Subsequently Gregory, who had opportunity of more thoroughly investigating it, transferred it to the genus Diadesmis, to which it properly belongs. Grunow refers this species to the genus Dimeregramma, and makes the following observations:—"Of the Eunotia-like structure of the same there is no question; the margins of the front view are never so distinctly triundulate as in Smith's description; for the most part the middlemost elevation is found much stronger than the other two, in consequence of which it approaches Dimeregramma minor."—Verhand. der K. K., Zool. Bot. Gesel., Band xii., 1862, p. 377.

Gregory, Diat. of Clyde, p. 25, Pl. x., fig. 40, in which both side and front views are accurately delineated. Ralfs, in Pritch, p. 923. Rab. Fl. Eur., sect. 1, p. 260.

From stomachs of Ascidians, Roundstone Bay, Co. Galway.

Genus VII. BREBISSONIA, Grunow.

Frustules simple, stipitate.

The only species of this genus was by Smith described and figured under the name of Doryphora Boeckii. The genus Doryphora had been adopted by Kützing for the reception of a single species which was named by him Doryphora amphiceros. His definition of the genus was, "frustules simple, depressed on the secondary side, punctate, elliptico-lanceolate, stipitate." Bac. p. 74. Influenced, no doubt, by the consideration of the last named characteristic, Wm. Smith adopted the genus as the proper place for another form named by him Doryphora Boeckii, and to some extent amended the definition: "Frustules stipitate, lanceolate, or elliptical; valve with a median line; nodules obsolete."—B. D., Vol. i., p. 77. This definition is not quite correct as respects either of the species included under this generic designation, for Doryphora amphiceros has no median line, properly so called; and the nodules, though small, are not obsolete in the case of Doryphora Boeckii. The latter species, Ralfs, as Ehrenberg had done before, refers to the genus Cocconema, but properly remarks, "This species is, no doubt, wrongly referred to Cocconema, since both margins of the lateral valves are symmetrical. We regard it as a stalked Navicula; and find a central, though inconspicuous nodule, a fact which forbids it being placed in Doryphora, as Professor Smith proposed."—In Pritch., p. 878. Grunow transfers Doryphora amphiceros to his new genus Rhaphoneis, and recognising the intimate relationship of Doryphora Boeckii to Navicula, suggested the adoption of a new generic designation, Brebissonia. defining it simply as a stipitate Navicula.

Heiberg recognises the proper relationship of the species, as Ralfs and Grunow had done, but rejecting the stipitate character as of no consequence, described the form as Navicula Boeckii.—De Danske Diat., p. 85. At all events, it is better to drop the genus Doryphora, which has been so ill defined, lest confusion should arise from maintaining it, even though with a more precise definition; and, as I think that the stipitate mode of growth should not be regarded as of no importance, I adopt the suggestion of Grunow above referred to.

Brebissonia boeckii, Ehr. Marine.

Valve on side view lanceolate. Striæ costate, close, radiate, median line obvious, with large end nodules, and ending towards the central nodule, in pin-head-like expansions; central nodule long and narrow, with a narrow free space at each side of the median line. (Pl. 29, fig. 22.)

Grunow, Verhand. der K. K., Zool. Bot. Gesel., Band x., 1860, p. 512.—Cocconema boeckii, Ehr. Infus., T. xix., fig. 5. Kütz. Bac., p. 81, T. vi., fig. 5. Ralfs, in Pritch., p. 878, Pl. vii., fig. 48. Rab. Fl. Eur., sect. i., p. 83.—Doryphora boeckii, Wm. Sm., B. D., Vol. i., p. 77, Pl. xxiv., fig. 223.—Navicula boeckii, Heiberg, De Danske Diat., p. 85.

Stomachs of Ascidians, Roundstone Bay, Co. Galway. Salt ditch on banks of Slaney, near Wexford. River Slaney, Killurin, Co. Wexford.

Genus VIII. NAVICULA, Bory.

Frustules simple, free.

Ehrenberg separated the forms included in this genus into two distinct genera, Navicula and Pinnularia, founded on the fact that in the former the striæ are moniliform, in the latter costate. Considerable difference of opinion has existed as to whether or not this distinction is tenable. Kützing rejected it, while Wm. Smith and Rabenhorst maintained its validity. Ralfs, in Pritch., p. 892, included the species of Pinnularia under the genus Navicula for the following reasons:—"Were the costæ always plainly developed, as in Pinnularia nobilis and its allies, no difficulty could occur in determining the genera; but in many of the more minute species it is often very difficult to distinguish between striæ and costæ. We have not admitted Pinnularia here, partly for the reason just given, but principally because we cannot decide to which genus a large number of Ehrenberg's species should be referred." The existence of the distinctive characteristic is here admitted, but the genus founded upon it is discarded on account of the difficulty of applying it in many cases. Grunow regards the distinction between costate and moniliform striæ, in this case, as founded on insufficient observation. He says, "The so-called costæ in the Pinnulariæ are quite distinct from the ribs of other genera of Diatomaceæ, and consist of a union of more or less confluent puncta, which cannot, indeed, be clearly discriminated, except by the help of good amplification and well-managed illumination."—Ueber neue oder ungenügend gekannte Algen, Verhand der K. K. Zool. Bot. Gesel., Band x., 1860, p. 513. This eminent author thus discards the distinction between Navicula and Pinnularia, and is followed by Heiberg, Cleve, and others. Schumann, who adopts the same view, indicates a peculiarity in some of the larger forms of Pinnularia, (P. nobilis and P. major, for example,) which is worthy of special notice here, namely, the interposition of very fine striæ between the costæ, which he says are indistinct in P. nobilis, but quite distinct in P. major; these interstitial markings I have never been able to discover, and Pfitzer makes the same remark concerning them. The last-named author, in his treatise "Untersuchungen ueber Bau und Entwicklung der Bacillariaceen" maintains the distinctiveness of the genus Pinnularia, not on the ground of the different character of the striation, but on the following peculiarities:—1st. The so-called costæ are depressions on the surface of the valve. 2nd. The valves themselves are unsymmetrical. 3rd. The arrangement of the cell-contents exhibits a marked difference from those of Navicula, as well in the normal condition as also in the process of self-division.—Regarding the characteristics just named, some remarks are here required. As to the first, supposing it to be true, there is great difficulty in applying it in the more minute forms.

As to the second, Pfitzer is at variance with most other authors who have regarded the forms included under the genus Pinnularia as perfectly symmetrical, and to me they have ever appeared just as symmetrical as those of Navicula. The third characteristic is that which is most worthy of notice, but the forms in which the peculiarity has been observed are comparatively few. So that we are not as yet in a position to regard it as satisfactorily established. For myself I have long since regarded the distinction between Navicula and Pinnularia as unsatisfactory, and have felt obliged to abandon it in consequence of having observed forms in which the costate character of the Pinnulariæ is combined with the moniliform striæ of the Naviculæ. In consequence of this there is no alternative but the abandonment of the genus Pinnularia, or the adoption of a new genus to receive these forms in which the characteristics of Navicula and Pinnularia are combined. The former appears the more satisfactory course, which I have accordingly pursued. The forms belonging to this genus are now so very numerous some more satisfactory grouping of them than that of Smith and Ralfs, founded on the outline of the valves, is necessary. Grunow has done much towards supplying this desideratum, and, if I have succeeded in effecting an improved arrangement, I am indebted to the hints supplied by that distinguished naturalist.

Conjugation has been observed in some species of Navicula. Two mother cells produce two sporangial cells or auxospores, as Pfitzer designates them, which latter are found to lie in a position parallel to that of the former.

(a.) *Nobiles.*

Striæ strongly costate, not extending to the median line, but leaving a broad, smooth, longitudinal middle space, which is expanded around the central nodule, and occasionally extending to the margin.

Navicula nobilis, (Ehr.) Fresh water.

Valve large, varying in length from ·012 to ·015; oblong, inflated both at the middle and ends; costæ broad, converging in the middle, and slightly radiate towards the ends; longitudinal free median space expanded greatly at the centre and ends. (Plate 30, fig. 1.)

Kütz. Bac., p. 98, T. iv., fig. 24. Ralfs, in Pritch., p. 895. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 515. Cleve, Om Svenska och Norska Diat., p. 223.—Pinnularia nobilis, Ehr. Proc. Berl. Acad., 1840. Wm. Sm., B. D., Vol. i., p. 54, Pl. xvii., fig. 161. Rab. Süssw. Diat., p. 44, T. vi., fig, 2; Rab. Fl. Eur., Alg., sect. 1, p. 209.

Bantry, Co. Cork. Featherbed Mountain, Co. Dublin. Lugnaquilla, Co. Wicklow. Lough Mourne deposit, Co. Antrim. Dromore sub-peat deposit, Co. Down. River Bann, at Coleraine, Co. Derry. Drumoughty Lough, near Kenmare, Co. Kerry.

Navicula major, (Kütz.) Fresh water.

Valve about the same length as that of N. nobilis; oblong, but very slightly expanded in the middle, and at the rounded, somewhat conical, ends; longitudinal free space narrower than that of N. nobilis; costæ broad, converging in the middle, and nearly parallel for the remainder. On front view frustule linear with rounded angles.

Kütz. Bac., p. 97, T. iv., fig. 19. Ralfs, in Pritch., p. 896. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 515. Heiberg, De Danske Diat., p. 80. Cleve, Om Svenska och Norska Diat., p. 223.—Pinnularia major, W. Sm., B. D., Vol. i., p. 54, Pl. xviii., fig. 161. Rab. Süssw. Diat., p. 42, T. vi., fig. 5. Do. Fl. Eur. Alg., sect. 1, p. 210.

Lower Lake, Killarney, River near Glencar, Co. Kerry. River Bann, near Coleraine, Co. Derry. Marl pit, near Arklow, Streamlets on Carrickmacreilly Hill, Greenane, Co. Wicklow. Derrylane Lough, Co. Cavan. Killakee, Featherbed Mountain, Co. Dublin. Slieve Donard, Co. Down. Lough Mourne deposit. Dromore Sub-peat deposit. Lough Islandreavy deposit. Pond near Camolin, Co. Wexford.

Navicula cardinalis, (Ehr.) Fresh water.

Valve oblong-linear, length about ·0125; breadth about ·0022, rounded at the ends; median line undulate; end nodules large; free intermediate space wide, reaching the margin in the middle, forming a broad stauroform space; costæ broad, converging in the middle, nearly parallel for the remainder. (Pl. 30, fig. 2.)

Ralfs, in Pritch., p. 806, Pl. xii., fig. 72. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 515.—Pinnularia cardinalis, Ehr. Wm. Sm., B. D., Vol. i., p. 55, Pl. xix., fig. 166. Rab. Fl. Eur. Alg., sect 1, p. 220.—Stauroneis cardinalis, Kütz. Bac., p. 106, T. xxix., fig. 10.

Lough Mourne deposit; found also living in a pond near the city of Armagh.

Navicula viridis, (Nitzsch.) Fresh water.

Valve varying much in size; linear elliptical, with rounded ends; intermediate free space narrower than in the three preceding species, and not so much expanded in the middle; costæ broad, but not so much so as in the preceding. (Pl. 30, fig. 3.)

This species has been attributed to various authors, but if Kützing be right in supposing it to be = Bacillaria viridis, Nitzsch, 1817, it should be attributed to the last named author, as Heiberg has done. Smith assigns the species to himself, although regarding it as = Navicula viridis, Ehr. Rabenhorst attributes it to himself, while Grunow attributes it to Kützing. Grunow makes this form the type of the group Virides, but seems to regard Navicula major, which he includes among the Nobiles, to be only a variety of Navicula viridis. Speaking of this former, he says, "it appears to me to be only a variety of Nav. viridis, tolerably numerous figures (especially from specimens out of the Kieselguss of Franzensbad), which lie before me, present such manifold transitions, as well in respect to the appearance of the striation as to the outline of the form, that in most cases it is difficult to decide whether the specimen should be referred to one or the other." Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 515.

The correctness of this remark is obvious to all careful observers, but still the species seem to be distinct. The following characters seem to distinguish Navicula viridis from N. major; the costæ are finer and less radiate; the median free space is narrower and less expanded around the central nodule, and the normal outline is linear elliptical.

Kütz. Bac., p. 97, T. iv., fig. 18. Ralfs, in Pritch., p. 907, Pl. ix., figs. 135, 136. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 518. Heiberg, De Danske Diat., p. 80. Cleve, Om Svenska och Norska Diat., p. 223.—Pinnularia viridis, Wm. Sm., B.D., Vol. i., p. 54, Pl. xviii., fig. 163. Rab. Süssw. Diat., p. 42, T. vi., fig. 4.

Featherbed Mountain, Friarstown, Co. Dublin. River Erne, near Crossdoney, Derrylane Lough, Co. Cavan. Ditch near Cushendun, Co. Antrim, Drumoughty Lough, near Kenmare, Lower Lake, Killarney. River near Glencar, Co. Kerry. Greenane Carrickmacreilly Hill, Lugnaquilla, Co. Wicklow. Lough Corrib, Co. Galway. Lough Mourne deposit, Sub-peat deposit, Dromore, Co. Down.

Navicula alpina, (Wm. Sm.) Fresh water.

Length of valves about ·0060, breadth about ·0018; broadly elliptical, with rounded ends; intermediate free space wide, but slightly expanded around the central nodule; costæ broad, convergent in the middle, and radiate towards the ends. (Pl. 30, fig. 4.)

Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 522.—Pinnularia alpina, Wm. Sm., B. D., Vol. i., p. 55, Pl. xviii., fig. 168. Rab. Fl. Eur. Alg., sect. 1, p. 213.

On the slopes of Slieve Donard, Co. Down. Killakee, Featherbed Mountain, Co. Dublin.

Navicula pachyptera, (Ehr.) Fresh water.

Frustules regularly quadrangular on front view; length of valve about ·0034, breadth about ·0013; slightly inflated in the middle, rounded at the ends; intermediate free space but slightly expanded in the middle; costæ broad, slightly converging in the middle, and nearly parallel for the remainder. (Plate 30, fig. 5.)

Kütz. Bac., p. 98, T. xxviii., fig. 58. Ralfs, in Pritch., p. 896, who considers the species distinct from Pinnularia lata, Wm. Smith, which latter he refers to as Navicula lata, p. 908. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 515.—Pinnularia pachyptera, Rab. Süssw. Diat., p. 44, T. vi., fig. 11.—Pinnularia lata, Wm. Sm., B. D., Vol. i., p. 55, Pl. xviii., fig. 167. Kützing describes a form as Navicula lata, Bac., p. 92, T. iii., fig. 51, which is obviously different from the present.

Pool, Glencree, Co. Wicklow. River Dodder, Featherbed Mountain, Co. Dublin. River Bann, near Hilltown, Co. Down.

Navicula distans, (Wm. Sm.) Marine.

Frustule on front view slightly constricted in the middle, and gently attenuated at the ends; valve lanceolate, length about ·0045, breadth about ·0010; costæ not so robust as in the preceding; convergent; intermediate free space lanceolate, much expanded in the middle and narrow towards the ends. (Plate 30, fig. 6.)

Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 523. Ralfs, in Pritch., p. 907. Cleve, Om Svenska och Norska Diat., p. 224. —Pinnularia distans, Wm. Sm., B. D., Vol. i. p. 56, Pl. xviii., fig. 169. Rab. Fl. Eur. Alg., sect. 1, p. 214.

Sea-weeds, Bannow, Co. Wexford. Sea-weeds, Malahide, Stomachs of Pectens, Dalkey, Piles of wooden bridge, Dollymount Strand, Sea-weeds, Howth, Co. Dublin. Stomachs of Ascidians, Belfast Lough, Co. Antrim. Stomachs of Ascidians, Co. Clare. Sea-weeds, Kilkee, Co. Clare.

Navicula undulata, N. S. Marine.

Length of valve ·0060, breadth, ·0015; lanceolate with rounded ends; median line undulate, intermediate free space lanceolate, greatly expanded in the middle; costæ strong, convergent. (Pl. 30, fig. 7.)

Sea-weeds, Giants' Causway, Co. Antrim.

Navicula rectangulata, (Gregory.) Marine.

Valve linear; length about ·0040, breadth about ·0010; slightly expanded at the middle and ends, which latter are rounded; intermediate free space narrow at ends, but roundly expanded in the middle; costæ strong, converging in the middle, and radiate towards the ends; frustule on front view constricted in the middle. (Plate 30, fig. 8.)

Gregory, Diat. of Clyde, p. 479, Pl. ix., fig. 7. Donkin, N. H. Brit. Diat., p. 66, Pl. x., fig. 5.—Pinnularia rectangulata, Rab. Fl. Eur. Alg., sect. 1, p. 215.

Stomachs of Ascidians, Broadhaven, Co. Galway.

Navicula trevelyana, (Donkin.) Marine.

Frustule on front view deeply constricted, with truncate extremities; middle and end nodules apparent, with a narrow slightly lunate unstriate band at either side of the central nodule; valve linear, rounded at ends; length about ·0048, breadth about ·0008; median line somewhat undulate; intermediate free space narrow, except around the median nodule, where it is much and roundly expanded; costæ strong, converging in the middle, and radiate towards the ends. (Plate 30, fig. 9.)

Donkin, Q. J. M. S., 1861, p. viii., Pl. 1, fig. 2. Do. N. H. Brit. Diat., p. 66, Pl. 10, fig. 6.—Pinnularia trevelyana, Rab. Fl. Eur. Alg. sect. i., p. 210.

Bannow, Co. Wexford. Malahide, Co. Dublin.

Navicula oblonga, (Kütz.) Fresh water.

Frustules on front view quadrangular, narrow; valve narrow, elliptical; length about ·0058, breadth about ·0007; apices broad, rounded; costæ strong, convergent; intermediate free space narrow, except in middle, where it is roundly expanded. (Pl. 30, fig. 10.)

Kütz. Bac., p. 97, T. iv., fig. 21. Ralfs, in Pritch., p. 907. Grunow, Verhand. der K. K., Zool. Bot. Gesel, Band x., 1860, p. 523. Cleve, Om Svenska och Norska Diat., p. 225.—Pinnularia oblonga, Wm. Sm. B. D., Vol. i., p. 54, Pl. xviii., fig. 165. The form described by Rabenhorst, Süssw. Diat., p. 45, T. vi., fig. 6, as Pinnularia oblonga, is obviously different from the present species.

Castlebridge, Co. Wexford. River near Glencar, Co. Kerry. Pond, Newcastle-Lyons, Co. Dublin. Powerscourt Demesne, Kilcool, Co. Wicklow.

Navicula oblonga, var. lanceolata, (Grunow.) Fresh water.

Valve shorter and broader than in the typical form, lanceolate, with rounded ends; intermediate free space narrow.

Grunow remarks that this variety "stands near to Pinnularia peregrina, as described by Wm. Smith," but it is certainly distinct, being found in localities beyond the reach of marine influence. It may be distinguished from Navicula peregrina by the intermediate free space, expanded in the middle, which that form does not exhibit.

Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1866, p. 523, T. iv., fig. 25.

Lough Mourne deposit, Co. Antrim.

Navicula longa, (Gregory.) Marine.

Valves lanceolate; length about ·0060; breadth about ·0010; costæ strong, distant, slightly radiate in the middle, more radiate

towards the ends; intermediate free space narrow, except in the centre, where it is somewhat rhombically expanded. (Pl. 30, fig. 11.)
Ralfs, in Pritch., p. 906. Donkin, N. H. Brit. Diat., p. 55, Pl. viii., fig. 3.—Pinnularia longa, Gregory, Q. J. M. S., Vol. iv., 1856, p. 47, Pl. 5, fig. 18. Rab. Fl. Eur. Alg., sect. i., p. 218.

Arran Islands; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula divergens, (Wm. Sm.) Fresh water.
Valve oblong; length from about ·0035 to ·0055, breadth, from about ·0007 to ·0012. Gibbous in the middle, attenuated towards the slightly constricted and rounded extremities. Costæ strong, convergent in the middle, and radiate towards the ends. Intermediate free space narrowed towards the ends, where there is a slight expansion; greatly expanded in the middle, reaching the margin in a tolerably broad stauroform band.
Ralfs, in Pritch., p. 896. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 523. Cleve, Om Svenska och Norska Diat., p. 225.—Pinnularia divergens, Wm. Sm., B. D., Vol. i., p. 57; Pl. xviii., fig. 177. Rab. Fl. Eur. Alg. sect. i., p. 221.

Drumoughty Lough, near Kenmare, County Kerry. Featherbed Mountain, Killakee, County Dublin. Bantry, County Cork. Lake near Castlewellan, County Down. Lough Mourne deposit, County Antrim.

Navicula divergens, var. longa, (O'Meara.) Fresh water.
Valve oblong, linear. Length about ·0059; breadth about ·0008; very slightly expanded in the middle and at the rounded ends. Costæ as in the typical form; intermediate free space as in typical form, but scarcely reaching the margin, compared with which it is relatively narrower in middle, and broader at the ends. (Pl. 30, fig. 13.)

Pond near the City of Armagh.

Navicula divergens, var. elliptica, (O'Meara.) Fresh water.
Like the typical species but broadly elliptical.

Lough Mourne deposit, Co. Antrim.

Navicula borealis, (Ehr.) Fresh water.
Valve narrow, elliptical, with rounded ends. Length about ·0015; breadth about ·0004. Costæ short, parallel; intermediate free space relatively wide, elliptical. (Pl. 30, fig. 14.)
Kütz. Bac. p. 96. T. xxviii., figs. 68 72, (where it is identified with Pinnularia borealis, Ehr.) Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 518.—Pinnularia borealis, Rab. Süssw.

Diat., p. 42, T. vi., fig. 19. Do. Fl. Eur. Alg., sect. 1, p. 216 (where it is identified with Pinnularia latestriata.) Gregory Q. J. M. S., Vol. ii., 1854, Pl. iv., fig. 13. Wm. Sm., B. D., Vol. ii., p. 94.

Drumoughty Lough, near Kenmare, Co. Kerry. Pond near Glenchree, Co. Wicklow. Ulster Canal, near Poyntzpass, Co. Armagh. Loughbrickland, Co. Down. Cushenden, Lough Neagh, Co. Antrim, Featherbed Mountain, Co. Dublin.

Navicula menapiensis, N. S. Marine.

Valve small; length ·0016; breadth ·0005; linear, ends rounded and slightly conical. Costæ marginal, distant; intermediate free space tolerably wide, linear elliptical. (Pl. 30, fig. 15.)

This form is, in some respects, similar to the last, but striæ are longer; otherwise distinguished by its marine habitat.

Sea-weeds, Bannow, Co. Wexford. Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula tabellaria, (Ehr.) Fresh water.

Valve oblong, slightly expanded at the middle and ends. Length about ·0050; breadth about ·0007. Costæ strong, convergent in the middle, then parallel and radiate towards the ends; intermediate free space wide, roundly expanded in the middle. (Plate 30, fig. 12.)

Kütz. Bac., p. 98, T. xxviii., figs. 79, 80, where the costæ are described incorrectly as reaching the median line; also T. xxx., fig. 20, where the costæ are represented as marginal, whereas they extend much further towards the median line. Grunow, Verhand. der K. K. Zool. Bot. Gesel., Band x., 1860, p. 516. Ralfs, in Pritch., p. 896, Pl. xii., fig. 21. Cleve, Om Svenska och Norska Diat., p. 224. Donkin., N. H. Brit. Diat., p. 70, Pl. xii., fig. 4.—Pinnularia tabellaria, Ehr. Wm. Sm., B. D., Vol. i., p. 58, Pl. xix., fig. 181. Rab. Süssw. Diat., p. 44, T. vi., fig. 24. Do. Fl. Eur. Alg., sect. i., p. 211.

Friarstown, Piperstown, Featherbed Mountain, Killakee, Co. Dublin. Glenchree, Lugnaquilla Mountain. Co. Wicklow. Glencar, Co. Kerry. Lough Corrib, Co. Galway. Lough Mourne deposit, Co. Antrim.

Navicula tabellaria, var. acrosphæria, (De Brèb.) Fresh water.

Like the typical form. The costæ, however, are marginal.

Navicula acrosphæria, Kütz. Bac., p. 97, T. v., fig. 11, where it is alleged that the form is identical with Frustulia acrosphæria, De Brèbisson, to whom, on this account, I attribute the species. Ralfs, in Pritch., p. 896.—Navicula tabellaria, Grunow, who observes, that "Wm. Smith's figures and descriptions of Navicula acrosphæria and N. tabellaria differ only in the different size and the somewhat thicker striation of the former species." Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 516.—Navicula acrosphæria. De Brébisson, Consid. sur les Diat., 1838, p. 19. Donkin, N.H. Brit. Diat., p. 72, Pl. xii., fig. 2.—Pinnularia acrosphæria, Wm. Sm., B. D., Vol. i., p. 58, Pl. xix., fig. 183.—Pinnularia tabellaria, var. acrosphæria, Rab. Fl. Eur. Alg., sect. i., p. 211.

Carnew, Greenane, Co. Wicklow. Lake near Castlewellan, Co. Down. Camolin, Co. Wexford.

(b.) *Gibbosæ.*

Similar to the Nobiles; the striæ finer; the intermediate free space narrower, expanding around the central nodule, and sometimes extending to the margin in a stauriform band.

Navicula clepsydra, (Donkin). Marine.

Frustules on front view constricted in the middle; ends angular; side view largely apparent. Valves narrow, elliptical; ends rounded. Length about ·0040; breadth about ·0009. Striæ punctate, converging in the middle; slightly radiate towards the ends; intermediate free space linear, narrow, except in the centre, where it is roundly expanded. (Plate 30, fig. 16.)

Donkin, Q. J. M. S., 1857, p. 8, Pl. i., fig. 3. Do., N. H. Brit. Diat., p. 63, Pl. x., fig. ii. Rab. Fl. Eur. Alg., sect. i., p. 181.

Ireland's Eye, Co. Dublin.

Navicula rupestris, N. S. Fresh water.

Valve in length ·0025; breadth ·0008; linear, elliptical, very gently attenuated towards the rounded ends. Striæ costate, fine, waved, converging in the middle, radiate towards the ends; intermediate free space narrow, except in the middle, where it is expanded in a rhomboid form. (Pl. 30, fig. 17.)

Found on moist rock, Portrush, Co. Antrim.

Navicula ceres, (Schumann). Marine.

Valve linear, elliptical; gently attenuated towards the rounded ends. Length ·0022; breadth ·0007. Striæ costate, in some lights appearing as if closely moniliform; convergent in the middle; slightly radiate towards the ends; intermediate free space narrow, except in the middle, where it is greatly expanded. (Pl. 30, fig. 18.)

Schumann, Preussische Diatomeen; Zweite Nachtrag, p. 56, T. ii., fig. 38.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula gibba, (Ehr.) Fresh water.

Valve nearly linear; very slightly constricted towards the ends, and very gently expanded in the middle. Length about ·0044; breadth about ·0008. Striæ finely costate; convergent in the middle, and radiate towards the ends. Intermediate free space narrow, except in the middle, where it is roundly expanded. (Pl. 30, fig. 19.)

Kützing, (Bac., p. 98, T. xxviii. fig. 70), has described a form under this name, which he regards as Pinnularia gibba, Ehr. With this the form so named by Rabenhorst (Süssw. Diat., p. 45, T. vi., fig. 27), agrees. Ralfs' description seems tolerably well to correspond, "lanceolate, with dilated capitate ends." In the above cases the figures represent the form more gibbous in the middle than the present species, and with capitate ends; the striæ also are parallel, while in the present form they are convergent in the middle, and radiate at the ends, just as Wm. Smith has figured Pinnularia gibba, B. D. Vol. i., p. 58, Pl. xix., fig. 180. The present form is less capitate at the ends, and the intermediate free space more roundly expanded in the middle than in Smith's figure. Grunow, comparing the species he has named Navicula gibba with Navicula tabellaria, says it stands distinct from it "by the narrower expansion of the ends, and the more gradual tapering in the middle." Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517. This description corresponds exactly with the present form.

Lough Corrib, Co. Galway. Drumoughty Lough, near Kenmare, Co. Cork. Carn Lough, near Tralee, Co. Kerry. Derrylane Lough, Co. Cavan. Carrickmacreely Hill, Lugnaquilla Mountain, Rathdrum, Co. Wicklow. Featherbed Mountain, Co. Dublin. Lough Mourne deposit, Co. Antrim.

Navicula gibba, var. boeckii, (Rab.) Fresh water.

Valve smaller than the typical species; length ·0032, breadth ·0007; margin very slightly gibbous; ends somewhat capitate; striæ finely costate; intermediate free space narrow, except at the middle, where it expands considerably, sometimes reaching the margin at one side, but not at the other. (Plate 30, fig. 20.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517, T. iv., fig. 17. This author regards the form as identical with Staurophora peckii, Rab. Bacil. Sachs.

Lough Corrib, Co. Galway. Pond near the city of Armagh.

Navicula gibba, var. parva, (O'Meara). Fresh water.

Valve small; length ·0015, breadth ·0003; slightly gibbous at the margins; much attenuated towards the somewhat-capitate ends; striæ costate, fine, convergent in the middle, and slightly radiate towards the ends; intermediate free space relatively broad, expanding at the middle, and sometimes reaching to the margin. (Plate 30, fig. 21.)

There is a form somewhat similar to this described by Grunow under the name of Navicula stauroptera, var. parva, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517, T. iv., fig. 19. The striation in the present form is, however, coarser than in Grunow's figure, the latter also being more robust, for which reasons I hesitate to identify the present form with that of Grunow.

Lough Neagh, near Lurgan, Co. Armagh. Camolin, Co. Wexford.

Navicula hemiptera, (Kütz). Fresh water.

Valve linear, elliptical, with rounded ends; length ·0025, breadth ·0005; striæ costate linear, convergent at the middle, and radiate towards the ends; intermediate free space narrow, somewhat expanded in the middle. (Plate 30, fig. 22.)

Kütz. Bac., p. 97, T. xxx., fig. 11. Ralfs, in Pritch., p. 908; Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519. This author considers the form may be only a variety of Navicula viridis, which it greatly resembles, except that it is smaller, and the striation very much finer. Cleve, Om Svenska och Norska Diat., p. 223.—Pinnularia hemiptera, Wm. Sm., B. D., Vol. ii., p. 95. Rab. Süssw. Diat., p. 42, T. vi., fig. 17. Do. Fl. Eur. Alg., sect. i. p. 212.

Lucan, Featherbed Mountain, Friarstown, Co. Dublin. River Erne, near Crossdoney, Derrylane Lough, Co. Cavan. Lough Erne, Co. Fermanagh. Lough Neagh, near Lurgan. Ulster Canal, near Poyntzpass, Co. Armagh. Pool near Glengarriff, Co. Cork. Streamlet, Cushendun, Co. Antrim. River Bann, near Coleraine, Co. Derry. Sub-peat deposit, Dromore, Co. Down.

Navicula apiculata, (De Brèb.) Marine.

Valve linear in the middle, gradually tapering towards the ends, which run out into acute short beaks; length ·0026, breadth ·0008; costæ fine, converging in the middle, radiate towards the ends; intermediate free space narrower towards the ends, expanded in the middle. (Pl. 30, fig. 23.)

Pinnularia rostellata, Gregory, Diat. of Clyde, p. 488, Pl. ix., fig. 20, 1857.—Navicula apiculata, De Brèbisson Diat. du Littoral de Cherbourg, p. 16, Pl. i., fig. 5, 1867. Ralfs, in Pritch., p. 903. Donkin N. H. Brit. Diat., p. 56, Pl. viii., fig. 6. Kützing has described a form as Navicula rostellata, which is quite distinct from the present; it is therefore necessary to drop the specific name adopted by Gregory, and substitute for it De Brèbisson's name, Navicula apiculata.

Gregory and De Brèbisson describe the striæ as reaching the median line; Donkin more correctly represents them as falling short of it, but does not describe the central expansion of the free intermediate space.

Navicula brèbissonii, (Kütz). Fresh water.

Valve linear, elliptical; ends somewhat rounded; length ·0016, breadth ·0005; costæ fine, radiate; intermediate free space narrow, except in the middle, where it expands, reaching the margin in a stauroform band widening towards the margin. (Plate 30, fig. 24.)

Kütz. Bac., p. 93, T. iii., fig. 49. Ralfs, in Pritch., p. 897. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519. —Pinnularia stauroneiformis, Wm. Sm., B.D., Vol. i., p. 57, Pl. xix., fig. 178. Rab. Fl. Eur. Alg., sect. i., p. 222.

Drumoughty Lough, near Kenmare, Bantry, Co. Cork. Derrylane Lough, Co. Cavan. Rathdrum, Featherbed Mountain, Co. Wicklow. Killakee, Co. Dublin. Lough Gill, Co. Kerry.

Navicula brèbissonii, var. angusta, (Grun.) Fresh water.

Valve narrow, elliptical; ends attenuated, and slightly rounded; length ·0016, breadth ·00025; costæ fine, radiate; intermediate free space narrow, except in the middle, where it expands, reaching the margin in a stauroform band narrower than in the typical species. (Plate 30, fig. 25.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519, T. v., fig. 18.

Derrylane Lough, Co. Cavan. Camolin, Co. Wexford.

Navicula icostauron, (Ehr.) Fresh water.

Valve linear, elliptical; length ·0028, breadth ·0006; costæ fine, radiate; intermediate free space narrow, except in the middle, where it expands into a narrow stauroform parallel band reaching the margin. (Plate 30, fig. 27.)

Stauroptera icostauron, Ehr., as Grunow suggests, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519.—Stauroneis icostauron, Kütz. Bac., p. 106, T. xxix., fig. 10.—Pinnularia viridis, var. B., Wm. Sm., B.D., Vol. i., p. 54, Pl. xviii., fig. 163 B.

Derrylane Lough, Co. Cavan. Adrigoole, Co. Kerry. Featherbed Mountain, Co. Dublin. Lake near Castlewellan, Co. Down.

Navicula stauroptera, (Grunow). Fresh water.

Valve linear, elliptical, with rounded ends; length ·0025, breadth ·0007; costæ coarse, convergent in the middle, radiate towards the ends; intermediate free space narrow, except in the middle, where it is much expanded, appearing sometimes to reach the margin, but really not so. (Plate 30, fig. 28.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 516. Stauroptera parva, Ehr., according to Kützing.—Stauroneis parva, Kütz. Bac., p. 106, T. xxix., fig. 23. Gregory has described a form as Pinnularia parva, Q. J. M. S., 1854, p. 98, Pl. iv., fig. 11. To avoid confusion, the specific name adopted by Ehrenberg and Kützing for this species had best be abandoned, and the designation proposed by Grunow as above substituted for it.

Raphoe, Co. Donegal. Lough Neagh, near Lurgan, Co. Armagh. Sub-peat deposit, Dromore, Co. Down.

Navicula bacillum, (Ehr.) Fresh water.

Valves linear; ends rounded; costæ fine, strongly marked in the middle, radiate; intermediate free space narrow, slightly expanded in the middle; length about ·0018, breadth about ·0005. (Plate 30, fig. 29.)

Ehrenberg has given many figures of a species so named, some of which are utterly undistinguishable; one from a marine habitat indicated cannot be the same. Two, however, of his figures are plain enough for satisfactory identification.

Ehr. Mic. T. xv., A. fig. 38; T. ii., 2. fig. 14. Kütz. Bac., p. 96, T. xxviii., fig. 69. Wm. Sm., B.D., Vol. ii., p. 91. Ralfs, in Pritch., p. 907. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 551, T. iv., fig. 1. Rab. Süssw. Diat., p. 39, T. vi., fig. 76. Heiberg, De Danske Diat., p. 85.

Ditch near town of Wexford. Lower Lake, Killarney, Co. Kerry. Lough Neagh, near Lurgan, Co. Armagh. Cushendun, Co. Antrim. Derrylane Lough, Co. Cavan. Sub-peat deposit, Dromore, Co. Down. Lough Mourne deposit.

Navicula americana, (Ehr.) Fresh water.

Valve linear, oblong, with rounded ends; length ·0035, breadth ·0010; slightly constricted; costæ fine, convergent in the middle, and nearly parallel towards the ends; intermediate free space wide, greatly expanded in the middle; central nodule large, median line very strongly marked. (Plate 30, fig. 30.)

Ehr. Mic. T. II., II., fig. 16. Kitton, Science Gossip, June, 1868, p. 131.

This species in a fossil state is widely dispersed; besides the locality indicated by Ehrenberg, it has been found by Mr. Kitton of Norwich, in Perley's Meadow deposit, Sth. Bridgton, Maine, U. S. A. I found it in great abundance in a fresh water deposit discovered by Dr. Moss, R. N., in Vancouver's Island, as also in a sub-peat deposit from Dromore, Co. Down. Rev. George Davidson has furnished me with specimens found in a fossil state in Lough Canmore, near Aberdeen. I have found it in tolerable abundance in a living state in Lough Neagh, near Lurgan, Co. Armagh.

Navicula isocephala, (Ehr.) Fresh water.

Valve long, narrow; length ·0055, breadth ·0007; undulate on the margin, with three nearly equal and slight inflations; ends constricted and capitate; costæ strong, convergent in the middle, and radiate towards the ends; intermediate free space narrow, except in the middle, where it is much expanded, reaching to the margin. (Plate 30, fig. 31.)

Kütz. Bac., p. 101, without a figure. This author identifies the species with Pinnularia isocephala, Ehr. Kitton, Science Gossip, June, 1868, p. 132.—Pinnularia monile, Rab. Fl. Eur. Alg., sect. i., p. 220.

Pond near the city of Armagh. Friarstown, Co. Dublin.

Navicula nodosa, (Ehr.) Fresh water.

Valve long and narrow; length ·0024, breadth ·0005; margin undulate, with three nearly equal inflations; costæ short, not very close, convergent in the middle, radiate towards the ends; intermediate free space wide, expanded in the middle. (Plate 30, fig. 26.)

Kütz. Bac., p. 101. T. xxviii., fig. 82. This author regards the form as identical with Navicula nodosa, Ehr. Infus., 1838, p. 179, T. xiii., fig. 9. Rab. Süssw. Diat., p. 41, T. vi., fig. 86. Gregory, Q. J. M. S., Vol. iv., 1856, p. 3, Pl. i., fig. 5. Pinnularia nodosa, Wm. Sm., B. D., Vol. ii., p. 96.

Friarstown, Featherbed Mountain, Co. Dublin. River Slaney, near Killurin. Camolin, Co. Wexford. Lake near Castlewellan, Co. Down. Kilcool, Lugnaquilla Mountain, Co. Wicklow.

Navicula nodosa, var. staurophora, (Grunow). Fresh water.

Valve smaller than in the typical species; length ·0016, breadth ·00025; inflations not so distinct; intermediate free space expanding in the middle into a distinct stauroform band reaching the margin. (Plate 30, fig. 26 a.)

Navicula nodosa, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 521, T. ii., fig. 21.

Navicula bicapitata, (O'Meara). Fresh water.

Valves small; length ·0020, breadth ·0006; linear, attenuated towards the capitate ends; costæ fine, convergent at the centre, radiate towards the ends; intermediate free space narrow, except at the middle, where it is roundly expanded, not reaching the margin. (Plate 30, fig. 32.)

Pinnularia biceps, Gregory, Q. J. M. S., 1856, p. 8, Pl. i., fig. 28. Kützing has described a form under the name of Navicula biceps, Bac., p. 96, T. xxviii., fig. 51, which is widely different from the present. Gregory's specific name must therefore be dropped.

Drumoughty Lough, near Kenmare, Co. Cork. Cawn Lough, near Tralee, Co. Kerry. River Bannow, near Clonegal, Co. Carlow. Kilcool, Co. Wicklow. Camolin, Co. Wexford.

Navicula bicapitata, var. crucifera. Fresh water.

Valve linear in the middle, attenuated towards the capitate ends. Length ·0024; breadth ·0006. Costæ fine, radiate; intermediate free space narrow, except in the middle, where it expands into a narrow stauroform band, reaching to the margin, and wider there than at the centre. (Pl. 30, fig. 33.)

Pinnularia interrupta, Wm. Sm., B. D., Vol. i., p. 59, Pl. xix., fig. 184. Were it not for the figure of Smith, just referred to, it would be difficult to identify this form. Smith alleges that it is identical with Stauroneis parva, Kütz. Bac., p. 106, T. xxix., fig. 23; but that form, as described by Kützing, is elliptical, and has not capitate ends, in consequence of which I consider the species quite distinct. The specific name adopted by Smith was previously appropriated by Kützing for a form belonging to the genus Navicula, which that form still retains; for which reason I have changed the specific designation.—Navicula parva, Ralfs, in Pritch., p. 897. This description is given obviously on the supposition that Pinnularia interrupta, (Wm. Sm.,) was identical with Stauroneis parva, Kütz. But a comparison of the figures renders the accuracy of this supposition more than doubtful.

Pool near Glengarriff, Co. Cork. Lough Gill, Co. Kerry. River at Port-na-Crush, Co. Donegal. Ditch, Cushendun, Co. Antrim. Gavagh, Co. Derry. Pool near Glenchree, Co. Wicklow.

Navicula bicapitata, var. constricta, (Grunow). Fresh water.

Valves slightly incurved in the middle; ends much produced, narrowed, and but slightly capitate. Length ·0025, breadth in middle ·0006. Costæ fine, radiate. Intermediate free space narrow, except in the middle, where it expands to the margin in a narrow stauroform band, widening at margin. (Pl. 30, fig. 34.)

Navicula mesolepta, var. constricta, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 521, T. iv., fig. 22, C. Inasmuch as the typical form of Navicula mesolepta has persistent costæ, whereas in the present case the costæ are obviously interrupted in the middle, I prefer to regard this form as a variety of Navicula bicapitata.

Featherbed Bog, Co. Dublin. Camolin, Co. Wexford.

Navicula termes, (Ehr.) Fresh water.

Valve narrow, oblong. Length ·0035, breadth ·0006; slightly incurved in the middle; ends much produced, slightly constricted. Costæ short, slightly radiate; intermediate free space wide, sometimes reaching the margin in a stauroform band. (Pl. 30, fig. 35.)

Navicula termes, var. nodulosa, Kütz. Bac., p. 101, T. xxviii., fig. 71, in which the costæ are represented as reaching the median line, whereas in the present form they are marginal. Kützing regards the

Navicula gibba, (Ehr.) Fresh water.

Valve nearly linear; very slightly constricted towards the ends, and very gently expanded in the middle. Length about ·0044; breadth about ·0008. Striæ finely costate; convergent in the middle, and radiate towards the ends. Intermediate free space narrow, except in the middle, where it is roundly expanded. (Pl. 30, fig. 19.)

Kützing, (Bac., p. 98, T. xxviii. fig. 70), has described a form under this name, which he regards as Pinnularia gibba, Ehr. With this the form so named by Rabenhorst (Süssw. Diat., p. 45, T. vi., fig. 27), agrees. Ralfs' description seems tolerably well to correspond, "lanceolate, with dilated capitate ends." In the above cases the figures represent the form more gibbous in the middle than the present species, and with capitate ends; the striæ also are parallel, while in the present form they are convergent in the middle, and radiate at the ends, just as Wm. Smith has figured Pinnularia gibba, B. D. Vol. i., p. 58, Pl. xix., fig. 180. The present form is less capitate at the ends, and the intermediate free space more roundly expanded in the middle than in Smith's figure. Grunow, comparing the species he has named Navicula gibba with Navicula tabellaria, says it stands distinct from it "by the narrower expansion of the ends, and the more gradual tapering in the middle." Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517. This description corresponds exactly with the present form.

Lough Corrib, Co. Galway. Drumoughty Lough, near Kenmare, Co. Cork. Carn Lough, near Tralee, Co. Kerry. Derrylane Lough, Co. Cavan. Carrickmacreely Hill, Lugnaquilla Mountain, Rathdrum, Co. Wicklow. Featherbed Mountain, Co. Dublin. Lough Mourne deposit, Co. Antrim.

Navicula gibba, var. boeckii, (Rab.) Fresh water.

Valve smaller than the typical species; length ·0032, breadth ·0007; margin very slightly gibbous; ends somewhat capitate; striæ finely costate; intermediate free space narrow, except at the middle, where it expands considerably, sometimes reaching the margin at one side, but not at the other. (Plate 30, fig. 20.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517, T. iv., fig. 17. This author regards the form as identical with Staurophora peckii, Rab. Bacil. Sachs.

Lough Corrib, Co. Galway. Pond near the city of Armagh.

Navicula gibba, var. parva, (O'Meara). Fresh water.

Valve small; length ·0015, breadth ·0003; slightly gibbous at the margins; much attenuated towards the somewhat-capitate ends; striæ costate, fine, convergent in the middle, and slightly radiate towards the ends; intermediate free space relatively broad, expanding at the middle, and sometimes reaching to the margin. (Plate 30, fig. 21.)

There is a form somewhat similar to this described by Grunow under the name of Navicula stauroptera, var. parva, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 517, T. iv., fig. 19. The striation in the present form is, however, coarser than in Grunow's figure, the latter also being more robust, for which reasons I hesitate to identify the present form with that of Grunow.

Lough Neagh, near Lurgan, Co. Armagh. Camolin, Co. Wexford.

Navicula hemiptera, (Kütz). Fresh water.

Valve linear, elliptical, with rounded ends; length ·0025, breadth ·0005; striæ costate linear, convergent at the middle, and radiate towards the ends; intermediate free space narrow, somewhat expanded in the middle. (Plate 30, fig. 22.)

Kütz. Bac., p. 97, T. xxx., fig. 11. Ralfs, in Pritch., p. 908; Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519. This author considers the form may be only a variety of Navicula viridis, which it greatly resembles, except that it is smaller, and the striation very much finer. Cleve, Om Svenska och Norska Diat., p. 223.—Pinnularia hemiptera, Wm. Sm., B. D., Vol. ii., p. 95. Rab. Süssw. Diat., p. 42, T. vi., fig. 17. Do. Fl. Eur. Alg., sect. i. p. 212.

Lucan, Featherbed Mountain, Friarstown, Co. Dublin. River Erne, near Crossdoney, Derrylane Lough, Co. Cavan. Lough Erne, Co. Fermanagh. Lough Neagh, near Lurgan. Ulster Canal, near Poyntzpass, Co. Armagh. Pool near Glengarriff, Co. Cork. Streamlet, Cushendun, Co. Antrim. River Bann, near Coleraine, Co. Derry. Sub-peat deposit, Dromore, Co. Down.

Navicula apiculata, (De Brèb.) Marine.

Valve linear in the middle, gradually tapering towards the ends, which run out into acute short beaks; length ·0026, breadth ·0008; costæ fine, converging in the middle, radiate towards the ends; intermediate free space narrower towards the ends, expanded in the middle. (Pl. 30, fig. 23.)

Pinnularia rostellata, Gregory, Diat. of Clyde, p. 488, Pl. ix., fig. 20, 1857.—Navicula apiculata, De Brèbisson Diat. du Littoral de Cherbourg, p. 16, Pl. i., fig. 5, 1867. Ralfs, in Pritch., p. 903. Donkin N. H. Brit. Diat., p. 56, Pl. viii., fig. 6. Kützing has described a form as Navicula rostellata, which is quite distinct from the present; it is therefore necessary to drop the specific name adopted by Gregory, and substitute for it De Brèbisson's name, Navicula apiculata.

Gregory and De Brèbisson describe the striæ as reaching the median line; Donkin more correctly represents them as falling short of it, but does not describe the central expansion of the free intermediate space.

Navicula integra, (Wm. Sm.) Fresh water.

Valve narrow, elliptic, incurved, then angularly expanded towards the ends which are narrow and papillate; striæ fine, radiate; intermediate free space narrow, except at the middle, where it is slightly expanded. (Plate 30, fig. 43.)

Ralfs, in Pritch., p. 895, who describes the striæ as reaching the median line. Donkin, N. H. Brit. Diat., p. 40, Pl. vi., fig. 8, where the character of the striæ is correctly delineated.—Pinnularia integra, Wm. Sm., B. D., Vol. ii., p. 96. Rab. Fl. Eur. Alg., sect. i, p. 220.

Powerscourt, Co. Wicklow.

Navicula pachycephala, (Rab.) Fresh water.

Valve elliptical, with capitate ends; length ·0022, breadth ·0006; costæ short, convergent; intermediate free space broad, reaching the margin in a narrow stauroform band. (Plate 30, fig. 44.)

Pinnularia pachycephala, Rab. Süssw. Diat., p. 43, T. vi., fig. 40.

Featherbed Mountain, Ballybrack, Co. Dublin.

Navicula subcapitata, (Gregory). Fresh water.

Valve narrow, linear, with subcapitate ends; costæ coarse and distant; intermediate free space relatively wide, linear; length ·0015, breadth ·0002. (Plate 30, fig. 45.)

Ralfs, in Pritch., p. 902.—Navicula gracillima, var. subcapitata, Rab. Fl. Eur. Alg., sect. i., p. 200.—Pinnularia subcapitata, Gregory, Q. J. M. S., 1856, p. 9, Pl. i., fig. 30.

Friarstown, Featherbed Mountain, Killakee, Co. Dublin. Glencar, Co. Kerry. Lake near Castlewellan, Co. Down.

Navicula gracillima, (Gregory). Fresh water.

Valve narrow, linear, with produced slightly capitate ends, length ·0018, breadth ·00025; costæ very fine, convergent in the middle, slightly radiate towards the ends; intermediate free space narrow, except in the middle, where it is roundly expanded. (Plate 30, fig. 46.)

Ralfs, in Pritch., p. 902. Rab. Fl. Eur. Alg., sect. i., p. 199. Schumann, Diat. der Hohen Tatra, p. 70, T. iv., fig. 49.—Pinnularia gracillima, Gregory, Q. J. M. S., 1856, p. 9, Pl. i., fig. 31. Wm. Sm., B. D., Vol. ii., p. 95.

Friarstown, Piperstown, Featherbed Mountain, Co. Dublin. Rathdrum, Lugnaquilla Mountain, Co. Wicklow. Drumoughty Lough, near Kenmare, Co. Cork. Glencar, Co. Kerry. Lake near Castlewellan, Co. Down.

Navicula macula, (Gregory). Marine.

Valve broadly elliptical, with narrowed truncate ends; length ·0014, breadth ·0008; costæ fine, parallel; intermediate free space narrow, except in the middle, where it expands greatly in quadrangular form. (Plate 30, fig. 47.)

Gregory, Q. J. M. S., 1856, p. 43, Pl. v., fig. 9. Ralfs, in Pritch., p. 896. Rab. Fl. Eur. Alg., sect. i., p. 189.

Lough Gill, Co. Kerry.

Navicula zellensis, (Grunow). Fresh water.

Valve narrow; length ·0016, breadth ·0003; ends produced; margin triundulate; striæ very fine; intermediate free space narrow, except at the middle, where it expands in a short narrow stauroform band. (Plate 30, fig. 48.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 521, T. iii., fig. 34. Rab. Fl. Eur. Alg., sect. 1, p. 207.

Lough Derryvaragh, Co. Westmeath. Camolin, Co. Wexford.

(c.) *Cuspidatæ.*

Valves more or less distinctly lanceolate; ends sometimes produced; median line distinct; intermediate free space narrow, bounded by two well-defined longitudinal ridges, one on either side of the median line.

Navicula cuspidata, (Wm. Smith). Fresh water.

Valve large, lanceolate; ends cuspidate; length about ·0070, breadth ·0015; striæ close, fine, linear, parallel; median line with slightly elongated expansions near the central nodule. (Plate 31, fig. 1.)

Kütz. Bac., p. 94, T. iii., figs. 24 and 27. Wm. Sm. B. D., Vol. i., p. 47, Pl. xvi., fig. 131. Rab. Süssw. Diat., p. 37, T. vi., fig. 16. This latter author remarks, that this form is very like Navicula fulva, but never attains the same size. This observation is not borne out by the specimens I have had the opportunity of examining; Navicula cuspidata is usually the larger, sometimes very much so. Ralfs, in Pritch., p. 905, Pl. xii., fig. 5. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 528. The form referred to by Grunow may possibly be different from the present, as he describes the striæ as somewhat radiate in the middle; the striæ in N. cuspidata being parallel all through. Heiberg, De Danske Diat., p. 82. Cleve, Om Svenska och Norska Diat., p. 228. Donkin, N. H., Brit. Diat., p. 39, Pl. vi., fig. 6.

Castlebridge, Tacumshane, Co. Wexford. Derrylane Lough, Stream, Crossdoney, Co. Cavan. Cushendun, Co. Antrim. Pond, Botanic Gardens, Belfast, Co. Down. Bellarena, Co. Derry. River

Dodder, Co. Dublin. Lough Gill, Co. Kerry. Powerscourt, Co. Wicklow. Lough Mourne deposit.

Navicula fulva. (Donkin). Fresh water.

Valve very much as the preceding, but smaller, and having the striæ somewhat radiate; length ·0032, breadth ·0007. (Pl. 31, fig. 2.)

There is great difficulty in identifying this form with that named Navicula fulva by Ehrenberg, which several authors identify with Navicula cuspidata.

This latter Smith has so accurately described, that there is no difficulty in identifying it, and therefore, under the circumstances, I attribute it to him. Donkin, too, has so figured Navicula fulva as to render it equally distinctive, and for this reason I assign the species to him.

Donkin, N. H., Brit. Diat,, p. 41, Pl. vi., fig. 9.

Lough Gill, Co. Kerry. Dysart, Co. Waterford.

Navicula cuspis, N. S. Marine.

Valves narrow, lanceolate; length about ·0044, breadth about ·0008; longitudinal sulci close to median line. Striæ linear, slightly radiate; ends cuspidate; dry valve a light straw colour. (Pl. 31, fig. 3.)

From stomachs of Ascidians, Co. Clare.

Navicula rhombica. (Gregory). Marine.

Frustules on front view subquadrate; slightly constricted angles, rounded. On side view, valve elliptical. Striæ fine, linear, converging in the middle, radiate; much finer and closer towards the ends; length ·0026, breadth ·0008. (Pl. 31, fig. 4.)

Gregory, Q. J. M. S., 1856, p. 38, Pl. v., fig. 1. Ralfs, in Pritch, p. 903. Rab. Fl. Eur. Alg., sect. i., p. 181.

Barrow, Co. Wexford. Malahide, Co. Dublin. Lough Gill, Co. Kerry. Seashore near town of Galway. Breaches, Co. Wicklow. Stomachs of Ascidians, Belfast Lough, Co. Antrim. Stomachs of Ascidians, Co. Clare.

Navicula cærulea, N. S. Fresh water.

Valve narrow, lanceolate: ends much produced. Length ·0022, breadth ·0005; longitudinal sulci close to median line. Striæ linear, convergent in middle, slightly radiate towards the ends; dry valve of a pale colour. (Pl. 31, fig. 5.)

Lough Mask, near Tourmakeady, Co. Mayo.

Navicula decipiens, N. S. Marine.

Valve narrow, elliptical, rounded at ends; length ·0030, breadth ·0008. Striæ fine, close, slightly radiate; in some lights apparently punctate; seemingly disappearing in the middle, and presenting the appearance of a narrow stauroform band, extending to the margins; this however is deceptive. (Pl. 31, fig. 6.)

Tide-pools, Galway Bay, near the town of Galway.

Navicula tumens. (Wm. Smith). Brackish or marine.

Valve elliptical; ends produced. Length from ·0024 to ·0040, breadth from ·0010 to ·0015. Striæ fine, punctate, slightly radiate; when not exactly in focus appearing to be moniliform. (Pl. 31, fig. 7.)

Smith has correctly described the character of the striæ in this species; but the figure represents the striæ as they appear when not in focus.

Donkin, N. H., Brit. Diat., p. 15, considers this form as identical with Navicula rostrata, Ehr., and Navicula sculpta, Ehr. These forms it appears were found by Donkin in the Bergmehl of Santa Fiore, and in the fossil deposit of Franzensbad, which I believe are both fresh water deposits, though that author assigns Navicula rostrata to brackish localities. The form under consideration has been found by Smith only in brackish water; and I have found it only in localities decidedly brackish or marine. However similar the forms may be, they seem to me perfectly distinct, and distinguishable by this feature, that in Navicula tumens the striæ run uninterruptedly from the margin to the longitudinal sulci, whereas in N. rostrata they are interrupted, and present an unstriate space between each sulcus and the ends of the striæ. Wm. Sm., B. D., Vol. i., p. 52, Pl. xvii., fig. 150. Ralfs, in Pritch., p. 900. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 541. Rab. Fl. Eur. Alg., sect. i., p. 192.

Salt ditch, near Newtownlimavady Junction, Co. Londonderry. Salt ditch, near the town of Galway. Seaweeds, Salt Hill, Co. Dublin. Salt ditch, Breaches, Co. Wicklow. Lough Gill, Co. Kerry.

Navicula rostrata. (Ehr.) Fresh or brackish water.

Valves elliptical, produced into long rounded apices; length ·0046, breadth ·0015. Striæ punctate, slightly radiate, disappearing in the middle of the space between the margin and the longitudinal sulcus, and appearing again upon the edge of the sulcus. (Pl. 31, fig. 8.)

There is some doubt as to whether this species belongs to fresh or brackish water. The fact that Donkin identified the form, so well delineated by him, with specimens from the Santa Fiore deposit, as well as that of Franzensbad, would seem decisive as to its proper habitat being in fresh water. The localities, however, to which he has assigned the species found by him in a living state are brackish;

and the only three localities in which I have found it in Ireland, if not marine, are certainly brackish.

Kütz. Bac., p. 94, T. iii., fig. 55, who attributes the species to Ehrenberg. Ralfs, in Pritch., p. 901, who regards it as distinct from Navicula sculpta, Ehr. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 540, who states that he did not find the form in the Santa Fiore Bergmehl. examined by him, but confirms Donkin's statement of having obtained it in the Franzensbad deposit. Donkin, N. H. Brit., Diat., p. 15, Pl. ii., fig. 9. Rab. Fl. Eur. Alg., sect. i., p. 197.

Seashore, Queenstown, Co. Cork. Breaches, Co. Wicklow. Salt Hill, Co. Dublin.

Navicula tenuirostris, N. S. Marine.

Valve elliptical, with long produced narrow apices; length ·0018, breadth ·0006; striæ fine, parallel in the middle, and slightly radiate towards the ends; less distinct midway between the margin and the longitudinal sulcus; intermediate free space narrow, apparently expanding in the middle in a short and very narrow stauroform band. (Plate 31, fig. 9.)

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula ambigua, (Ehr.) Fresh water.

Valves elliptical, ends produced and capitate; length ·0032, breadth ·0010; striæ fine, parallel. (Plate 31, fig. 10.)

Kütz. Bac., p. 95, T. xxviii., fig. 66, who attributes the species to Ehrenberg. Wm. Sm., B. D., Vol. i., p. 51, Pl. xvi., fig. 149. Rab. Süssw. Diat., p. 40, T. vi., fig. 59. Ralfs, in Pritch., p. 902. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 529, T. iv., fig. 33. Cleve, Om Svenska och Norska Diat., p. 228. Donkin, N. H., Brit. Diat., p. 39, Pl. vi., fig. 5.

River Erne, near Crossdoney, Co. Cavan. Pool near Glencar, Co. Cork. River Bann, near Coleraine, Co. Londonderry.

Navicula sphærophora, (Kütz.) Fresh water.

Valve elliptical; ends considerably produced and capitate; striæ fine, punctate, slightly convergent; length ·0030, breadth ·0010. (Plate 31, fig. 11.)

Kütz. Bac., p. 95, T. iv., fig. 17. Wm. Sm., B. D., Vol. i., p. 52, Pl. xvii., fig. 148, who represents the striæ as moniliform, an appearance they present only when not in focus. Rab. Süssw. Diat., p. 40, T. vi., fig. 65a, 65b being, as it would appear, a very distinct form. Ralfs, in Pritch., p. 899. Grunow, Verhand. der K. K. Zool. Bot.

Gesell., Band x., 1860, p. 540, T. iv., fig. 34. Cleve, Om Svenska och Norska Diat., p. 227. Donkin, N. H. Brit. Diat., p. 34, Pl. v., fig. 10.

Tacumshane, Co. Wexford. Lough Gill, Co. Kerry. Moist rock, Portrush, Co. Antrim. River Bann, near Coleraine, Co. Londonderry.

Navicula quarnerensis, (Grunow). Marine.

Valve broadly elliptical, slightly produced towards the apiculate ends; striæ fine, obscurely punctate, radiate; length ·0028, breadth ·0012. (Plate 31, fig. 12.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 530, T. iii., fig. 8, found in the Adriatic Sea, from two to four fathoms in depth.

Salt ditch, near Galway town. Stomachs of Ascidians, Roundstone Bay, Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula Davidsoniana, N. S. Marine.

Valve broadly elliptical; ends slightly produced, apiculate; striæ fine, linear, parallel in the middle, and slightly radiate towards the ends; central nodule large, elongate, longitudinal; sulci very distinct, slightly expanded in the middle. (Plate 31, fig. 13.)

From stomachs of Ascidians, Co. Clare.

Navicula ovulum, (Grunow). Marine.

Valve broadly elliptical; striæ fine, linear, slightly radiate in the middle, and more so towards the ends; longitudinal sulci strongly marked, and quite parallel through their entire length; central nodule small; colour of dry frustule pale yellow; length ·0024, breadth ·0011. (Plate 31, fig. 14.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 519, T. iii., fig. 19.—Navicula litoralis, Donkin, N. H. Brit. Diat., p. 5, Pl. i., fig. 2.

Malahide.

(d.) *Latiusculæ.*

Valves generally elliptical; ends sometimes produced; striæ fine; intermediate free space generally broad, and expanded in the middle; a submarginal longitudinal sulcus more or less distinctly developed.

Navicula latiuscula, (Kütz.) Fresh water.

Valve broadly elliptical; striæ delicate, parallel; length about ·0048, breadth ·0014; intermediate free space much expanded. (Plate 31, fig. 15.)

Kütz. Bac., p. 93, T. v., fig. 40. This form could scarcely have been identified, were it not that authentic specimens were seen by Wm. Smith, who considers it identical with his Navicula patula, B. D., Vol. i., p. 49, Pl. xvi., fig. 139. Ralfs, in Pritch., p. 905. Rab. Süssw. Diat., p. 38, T. vi., fig. 61. If in this case the figure be correct, it can scarcely be identified with Navicula latiuscula, Kütz. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 534, T. iv., fig. 38. Donkin, N. H., Brit. Diat., p. 27, Pl. iv., fig. 7. Rab. Fl. Eur. Alg., sect. i., p. 182.

Lough Corrib, Co. Galway. Killurin, Co. Wexford. Newtown-limavady, Co. Derry. Breaches, Newcastle, Co. Wicklow.

Navicula barkeriana, N. S. Marine.

Valve linear, elliptical, gradually attenuated towards the produced ends; striæ linear, fine, close, distinctly radiate; intermediate free space wide, greatly expanded in the middle; median terminating towards the central nodule in elongated expansions; length ·0052, breadth ·0014.

This form might be easily confounded with Navicula latiuscula, from which it differs in the following features: the intermediate free space is much wider, the ends are produced, and the striæ are radiate, and somewhat coarser. (Plate 31, fig. 16.)

On sea-weeds, Dalkey, Co. Dublin. Breaches near Newcastle, Co. Wicklow. In both these gatherings there was a considerable admixture of fresh water forms; the marine forms, however, greatly preponderated.

Navicula grunovii, (O'Meara). Fresh or brackish water.

Valve broadly elliptical, longitudinal, marginal sulci very distinct; intermediate free space wide, lanceolate, greatly expanded in the middle; median line slightly undulate; striæ fine, slightly radiate; length ·0040, breadth ·0016. (Plate 31, fig. 17.)

Navicula elegans, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 534, T. iv., fig. 37. This author confounds this form with Navicula elegans, Wm. Sm., of which he states he had never seen a specimen; and suggests that in case it should prove to be different from the last-named species it should be designated Navicula lacustris. Cleve, in his Diatoms of the Arctic Sea, p. 17, perceiving that the form was obviously distinct from Navicula elegans, adopts Grunow's alternative designation, which, however, must be abandoned, as the name had been applied by Gregory to designate a very different form. Grunow found this species in fresh water as well as in slightly brackish water, so that there is a difficulty in ascertaining the habitat. I cannot clear up this difficulty, inasmuch as the only gathering in which the form occurred to me contained both marine and fresh water forms.

Bellarena, Co. Derry.

Navicula amphisbæna, (Bory). Fresh water.

Valve broadly elliptical, with produced capitate ends, longitudinal sulci close to the margin; intermediate free space lanceolate, broad in the middle. Striæ fine, linear, close, radiate; length ·0035, breadth ·2013. (Pl. 31, fig. 18.)

Kütz. Bac., p. 95, T. iii., figs. 41 and 42. This author regards the species as identical with Navicula amphisbæna, Bory, 1824, to whom, therefore, it should be attributed. Wm. Sm., B. D., Vol. i., p. 51, Pl. xvii., fig. 147. Ralfs, in Pritch., p. 899, Pl. vii., fig. 72. Rab. Süssw. Diat., p. 40, T. vi., fig. 66. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 36. Heiberg, De Danske Diat., p. 82. Cleve, Om Svenska och Norska Diat., p. 227. Donkin, N. H. Brit. Diat., p. 36, Pl. v. fig. 13.

River Dodder, Dundrum, Blackrock, Malahide, Co. Dublin. River Bann, Coleraine, Bellarena, Co. Derry. Caumlough, near Tralee. Lough Gill, Co. Kerry. Breaches, near Newcastle, Co. Wicklow. Tacumshane, Co. Wexford.

Navicula subsalina, (Ehr.) Brackish water.

In all respects resembling Navicula amphisbæna, except that the ends are not capitate, nor so much produced.

Donkin, N. H. Brit. Diat., p. 24, Pl. iv., fig. 2.—Navicula amphisbæna, var. β. Wm. Sm., B. D., Vol. i., p. 51; Pl. xvii., fig. 147 β. The last-named author attributes the species to Ehrenberg. Cleve, Diatoms from Arctic Sea, p. 18. This form occurs frequently, mixed with Navicula amphisbæna, in places accessible to marine influences, but I have never found it in perfectly fresh water. So that, with Donkin, I am disposed to consider it may be a distinct species.

Tacumshane, Co. Wexford. Breaches, Co. Wicklow. Caumlough, near Tralee. Lough Gill, Co. Kerry. Malahide, Co. Dublin.

Navicula elegans, (Wm. Sm.) Marine or brackish water.

Valve elliptical, lanceolate; longitudinal sulci marginal. Striæ distinct, linear, convergent in the middle, afterwards radiate; intermediate free space narrow, except in the middle, where it expands considerably; length about ·0038, breadth about ·00065. (Pl. 31, fig. 19.)

Wm. Sm. B. D., Vol. i., p. 49. Pl. xvi. fig. 137. Ralfs, in Pritch., p. 907. Heiberg, De Danske Diat., p. 85. Rab. Fl. Eur. Alg., sect. i., p. 182. Donkin, N. H. Brit., Diat., p. 23, Pl. iv., fig. 1. This form is obviously distinct from that described under the name of Navicula elegans by Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, T. iv., fig. 37.

Blackrock, Co. Dublin. Caumlough, near Tralee. Lough Gill, Co. Kerry. Galway Bay. Breaches, Kilcool, Co. Wicklow. Tacumshane, Co. Wexford.

Navicula palpebralis, (De Brèb.) Marine.

Valve broadly elliptical, lanceolate at the ends; striæ distinctly costate, linear, radiate, marginal; intermediate free space wide, elliptical-lanceolate; length ·0034, breadth ·0013. (Pl. 31, fig. 20.)

Wm. Sm., B. D., Vol. i., p. 50. Supp., Pl. xxxi., fig. 273. The figure represents the striæ as minutely punctate; in reality they are strongly costate. Ralfs, in Pritch., p. 905. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 160, p. 536, T. iii., fig. 27. The form here described exactly resembles that of Smith, being very small, and with minutely punctate striæ. Donkin, N. H. Brit. Diat., p. 25, fig. 3. This author regards the species as identical with Navicula barclayana, Greg. Rab. Fl. Eur. Alg., sect. i., p. 182, who describes the striæ as distinctly granulate.

Stomachs of Ascidians, Broadhaven Bay, Arran Islands, Co. Galway.

Navicula angulosa, (Greg.) Marine.

Similar to the preceding, but striæ finer and closer, and longer, convergent in the middle, radiate towards the ends; intermediate free space, instead of being elliptical, is lanceolate; length ·0050, breadth ·0010.

Gregory, Q. J. M. S., 1856, p. 42, Pl. v., fig. 8. Ralfs, in Pritch., p. 905. Rab. Fl. Eur. Alg., sect. i., p. 176. Donkin, N. H. Brit. Diat., p. 26, Pl. iv., fig. 4.

River Slaney, Killurin, Tacumshane, Co. Wexford. Breaches, near Newcastle, Co. Wicklow. Malahide, Co. Dublin. Arran Islands, Co. Galway.

Navicula semiplena, (Gregory). Marine.

Valve as in the preceding form, but much narrower, and the intermediate free space not angular in the middle.

Donkin, N. H. Brit. Diat., p. 26, Pl. iv., fig. 5.—Pinnularia angulosa, var. β, Gregory, Q. J. M. S., 1856, p. 42, Pl. v., fig. 8*—Pinnularia semiplena, Greville, Q. J. M. S., 1859, p. 84, Pl. vi., fig. 12.

Malahide, Co. Dublin. Fintragh Bay, Co. Donegal. Rostrevor, Co. Down.

Navicula hebes, (Ralfs). Fresh water.

Valve gibbous in the middle, ends somewhat attenuated, but still broad, and rounded. Striæ fine, linear, nearly parallel; intermediate free space wide in middle, lanceolate towards the ends. (Pl. 31, fig. 21.)

Ralfs, in Pritch., p. 896, who regards the species as identical with Navicula obtusa, Wm. Sm., B. D., Vol. i., p. 50, Pl. xvi., fig. 140, with which I find it impossible to identify it. Donkin, N. H. Brit., Diat., p, 23, Pl. iii., fig. 12.

Marl, Co. Down. Lough Mourne deposit.

Navicula lineata, (Donkin). Marine.

Valve linear, elliptical, with cuneate ends; margin slightly curved. Striæ strong, convergent in the middle, and radiate towards the ends; longitudinal sulcus dividing the striæ into two nearly equal parts; intermediate free space broad, lanceolate towards either end, and expanded in the middle; length about ·0034, breadth about ·0010. (Pl. 31, fig. 22).

Donkin, Q. J. M. S., 1859, p. 32, Pl. iii., fig. 17. Also N. H., Brit. Diat., p. 8, Pl. i., fig. 8.

Seashore near the town of Galway.

Navicula liber, (Wm. Sm.) Marine.

Valve narrow elliptical, with rounded ends. Striæ fine, slightly radiate, divided into two nearly equal portions by the longitudinal sulcus; intermediate free space narrow towards the ends; slightly expanded in the middle; length from ·0030 to ·0045, breadth from ·0009 to 0012. (Pl. 31, fig. 23.)

Wm. Sm., B. D., Vol. i. p. 48, Pl. xvi., fig. 133. Ralfs, in Pritch., p. 907. Grunow, Verhand. der Zool. Bot. Gesell., Band x., 1860, p. 547. Cleve, Om Svenska och Norska Diat., p. 227. Rab. Fl. Eur. Alg., sect. i., p. 180. Donkin, N. H. Brit. Diat., p. 62, Pl. ix., fig. 5.

Salt ditch, near the town of Wexford. Lough Gill, Co. Kerry. Seaweeds, Kilkee, Co. Clare. Lough Foyle, near Newtownlimavady, Co. Derry. Breaches, near Newcastle, Co. Wicklow. Galway Bay.

Navicula bicuneata, (Grunow). Marine.

Valve deeply constricted in the middle, with long cuneate ends, somewhat rounded at the apex. Striæ linear, parallel; longitudinal sulcus nearer to the median line than to the margin; intermediate free space narrow, except in the middle, where it is slightly expanded; median line strongly developed; central nodule small, roundish; length ·0056, breadth at the shoulders ·0018, at the middle ·0015. (Pl. 31, fig. 24.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 546, T. iii., fig. 4. This author considers the form may be only a variety of Navicula liber, from which, however, it differs both in form and structure. The striæ in this are parallel, in Navicula liber slightly radiate. My specimens are generally wider at the shoulders, and more constricted than Grunow's figure represents them. Cleve, Om Svenska och Norska Diat., p. 227, T. i., figs. 3 and 4. The form, as represented by this last-named author, is even less constricted than Grunow's figure represents it. Cleve remarks:—"Grunow has not described the front view, which in the specimens examined by me were cuneate, as is the case in Gomphonema or Novilla; for which reason this species ought to be transferred to a new genus, distinguished from Navicula by the cuneate front view. The side view was sufficiently conformable with Grunow's description." The cuneate appearance of the front view just referred to, I am inclined to think, was casual, arising from the separation of the valves at one end, while at the other end they retained their normal position. In the specimen I was able to observe on the front view, there was but a single valve, which did not exhibit any tendency to a cuneate outline.

Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway. Bantry Bay, Co. Cork.

Navicula gründleriana, N. S. Marine.

Valve linear elliptical; somewhat cuneate at the ends; intermediate free space narrow, except in the middle, where it expands into a broad, subquadrangular area. Striæ linear, slightly radiate; longitudinal sulcus marginal. (Pl. 31, fig. 25.)

This form strongly resembles a Navicula figured by Schmidt, Atlas, T. vi,, figs. 31 and 32; and by this author attributed to Gründler. It differs however, inasmuch as the striæ in the latter are described as punctate; in the present case they are linear. The free area around the central nodule in this form is much larger than in that figured by Schmidt. The strong similarity has suggested the specific name.

The present form upon first view might be easily confounded with Navicula macula, Greg., from which it may be discerned by the fact that the ends in the latter are contracted and rounded; in this they are cuneate. The striæ, too, in this are very much coarser and more distant than in Nav. macula.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

(e) *Limosæ.*

Longitudinal sulci more numerous than in the last, and generally more highly developed; intermediate free space narrow.

Navicula iridis, (Ehr.) Fresh water.

Valve linear, elliptical, rounded off at the ends. Striæ fine, linear, parallel; intermediate free space narrow towards the ends, expanded in the middle; length from ·0046 to ·0072, breadth from ·0010 to ·0016. Longitudinal striæ distinct at the margin. (Pl. 31, fig. 26.)

Kütz. Bac., p. 92, T. xxviii., fig. 42. Ralfs, in Pritch., p. 907. Rab. Fl. Eur. Alg., sect. i., p. 171. Donkin, N. H. Brit. Diat., p. 30, Pl. v., fig. 6.—Navicula firma, Wm. Sm., B. D., Vol. i., p. 48, Pl. xvi., fig. 138. Smith's figure does not represent the longitudinal striæ, which more particularly characterize this species. Kützing's figure, though representing this peculiarity, does not give to it its due prominence.

Drumoughty Lough, near Kenmare, Co. Cork. Marsh, Kilcool, Glenmalure, Co. Wicklow. Lower Lake, Killarney, Co. Kerry. Ditch, Cushendun, Co. Antrim. Pond in Botanic Gardens, Belfast. Lough Mourne deposit, Co. Down.

Var. amphigomphus, (Ehr.) Fresh water.
Like the typical form in its general characters, but linear in its outline and cuneate at the ends; length from ·0025 to ·0045, breadth from ·0010 to ·0016. (Plate 31, fig. 27.)
Kütz. Bac., p. 93, T. xxviii., fig. 40. Rab. Süssw. Diat., p. 38, T. vi., fig. 47.—Navicula firma, Ralfs, in Pritch., p. 909. Donkin, N. H. Brit. Diat., p. 31, Pl. v., fig. 7.—Navicula firma, var. cuneata, Lagerstedt, Sötv. Diat. frän Spetsbergen och Beeren Eiland, p. 29.

Lower Lake, Killarney, Co. Kerry. Piperstown, Co. Dublin. River Erne, near Crossdoney, Co. Cavan. Kilcool, Co. Wicklow.

Var. affinis, (Ehr.) Fresh water.
Valve like the typical species, but narrow and linear in outline; ends produced, broad, rounded, and slightly constricted. (Plate 31, fig. 28.)
Navicula affinis, Kütz. Bac., p. 95, T. xxviii., fig. 65, who attributes the species to Ehrenberg. Wm. Sm., B. D., Vol. i., p. 50, Pl. xvi., fig. 143. Ralfs, in Pritch., p. 902, Pl. xii., fig. 32. Rab. Süssw. Diat., p. 40, T. vi., fig. 58. Cleve, Om Svenska och Norska Diat., p. 228. Donkin. N. H. Brit. Diat., p. 33, Pl. v., fig. 8. Lagerstedt, Sötv. Diat. frän Spetsbergen och Beeren Eiland, p. 29.

River Erne, near Crossdoney, Co. Cavan. Drumoughty Lough, near Kenmare, Glengarriff, Co. Cork. Bellarena, Co. Derry. Pond, Botanic Gardens, Belfast, Co. Down. Near Newcastle, Kilcool, Lugnaquilla mountain, Co. Wicklow. Killakee, Co. Dublin.

Navicula dubia, (Ehr.) Fresh water.
Valve like that of Navicula iridis, var. amphigomphus, but much smaller and broader in proportion; the cuneate ends extended into short apices; striæ in many specimens seen very slightly radiate; length ·0018, breadth ·0008. (Plate 31, fig. 29.)
Navicula dubia, Kütz. Bac., p. 96, T. xxviii., fig. 61, who attributes the species to Ehrenberg. Rab. Süssw. Diat., p. 40, T. vi., fig. 60. This latter figure is quite unlike the present species. Ralfs, in Pritch., p. 902. Donkin, N. H. Brit. Diat., p. 30, Pl. v., fig. 5.—Navicula peisonis, Grunow, Verhand. der K. K., Zool. Bot. Gesell.,

Band x., 1860, p. 544, T. iii., fig. 28: and likely also identical with Navicula limosa, var. bicuneata, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 545, T. v., fig. 7.

Lough Mask, near Tourmakeady, Co. Mayo. Kilcool, Co. Wicklow. Lough Gill, Co. Kerry. Pond in Botanical Gardens of Trinity College, Dublin.

Navicula limosa, (Kütz.) Fresh water.

Valve triundulate on the margin, more expanded in the middle than at the ends; ends cuneate; striæ fine, parallel; longitudinal free space narrow, except in the middle, where it is slightly expanded; longitudinal striæ easily observed, with good illumination; length about ·0034, breadth in the middle ·0006. (Plate 31, fig. 30.)

Kütz. Bac., p. 101, T. iii., fig. 50. Rab. Süssw. Diat., p. 41, T. vi., fig. 31. Ralfs, in Pritch., p. 894, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 544, T. v., fig. 86. Donkin, N. H. Brit. Diat., p. 73, Pl. xii., fig. 61. Cleve, Om Svenska och Norska Diat., p. 227. Lagerstedt, Sötv. Diat. frän Spetsbergen och Beeren Eiland, p. 30, T. i., fig. 6.

Powerscourt, Co. Wicklow. Botanical Gardens of Trinity College, Dublin.

Var. gibberula, (Kütz.) Fresh water.

Like the typical species, differing only in this, that the ends instead of being cuneate are rounded.

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 544, T. v., fig. 8a. Donkin, N. H. Brit. Diat., p. 73, Pl. xii., fig. 6a. —Navicula gibberula, Kütz. Bac., p. 101, T. iii., fig. 50. Wm. Sm., B. D., Vol. i., p. 51, Pl. xvii., fig. 160. Schumann, Diat. der Hohen Tatra, p. 76. Lagerstedt, Sötv. Diat. frän Spetsbergen och Beeren Eiland, p. 38.

River Erne, Crossdoney, Derrylane Lough, Co. Cavan. Glengarriff, Co. Cork. Lough Neagh, near Lurgan, Co. Armagh. Streamlet in Powerscourt demesne, Co. Wicklow. Lough Mourne deposit.

Var. truncata, (Kütz.) Fresh water.

Valve nearly linear, with rounded ends; the longitudinal sulci waved; length ·0025, breadth ·00055. (Plate 31, fig. 31.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 545, T. v., figs. 8e and 9.—Navicula truncata, Kütz. Bac., p. 96, T. iii., fig. 34, and T. v., fig. 4. Rab. Süssw. Diat., p. 39, T. vi., fig. 67.

Friarstown, River Dodder, Co. Dublin. Lough Neagh, near Lurgan, Co. Armagh. Lough Mask, near Tourmakeady, Co. Mayo. Dundalk, Co. Louth. Wet rock, Ballyshannon, Co. Donegal. Castle-Gregory, Co. Kerry.

Navicula undosa, (Ehr.) Fresh water.

Valve broadly elliptical, slightly triundulate; apices produced, very narrow, and slightly capitate; longitudinal striæ distinct; transverse striæ obscure; length ·0016, breadth ·0006. (Plate 31, fig. 32.)

Kütz. Bac., p. 101, T. xxviii., fig. 83. Rab. Süssw. Diat., p. 41, T. vi., fig. 56.

River Erne, near Crossdoney, Co. Cavan.

Navicula esox, (Ehr.) Habit. doubtful.

Valve lanceolate, with an angular expansion in the middle; margin slightly triundulate; ends cuneate; striæ distinct, linear, punctate, nearly parallel in the middle, slightly radiate and closer towards the ends; median line strongly developed; terminal nodules at some distance from the ends; length ·0034, breadth ·0010. (Plate 31, fig. 33.)

Kütz. Bac., p. 94, T. xxviii., fig. 53, who regards the species as identical with Pinnularia esox, Ehr. Ralfs, in Pritch., p. 896, Pl. xii., fig. 43. The description in this case is tolerably accurate, but the figure is incorrect.—Pinnularia esox, Rab Süssw. Diat., p. 45, T. vi., fig. 7. This figure does not at all represent the peculiarities of the species.

It is doubtful whether this is a fresh-water or marine form. Rabenhorst includes it among the former; the only gathering in which I found it was marine, yet containing some fresh water forms.

Mud from salt water, coast of Clare, supplied by Doctor Sullivan, President Queen's College, Cork.

Navicula trochus, (Ehr.) Fresh water.

Valve inflated in the middle, greatly contracted towards the ends, which are slightly capitate; transverse striæ indistinct; longitudinal striæ distinct; intermediate free space narrow, except in the middle, where it is expanded. (Plate 31, fig. 34.)

Kütz. Bac., p. 99, T. iii., fig. 59. Ralfs, in Pritch., p. 899.—Navicula follis, Donkin, N. H. Brit. Diat., p. 44, Pl. vi., fig. 15. There is considerable difficulty as to the synonymy of this species. Donkin considers it identical with Navicula follis, Ehr., Navicula crux, Ehr., and Navicula inflata, Kütz. Supposing the figures of the last named as delineated by Kützing (Bac., T. iii., fig. 36), and by Rabenhorst (Süssw. Diat., p. 41, T. v., fig. 10), to be correct, and that the former author was correct in supposing Navicula inflata to be identical with Navicula follis, Ehr., I cannot think that the latter is likely to be identical with Navicula trochus. Kützing has figured Navicula trochus so accurately, that it is easily recognisable; it is identical with that under consideration, and also, as it appears to me, with that named Navicula follis, by Donkin.

Lough Mourne deposit.

Navicula producta, (Wm. Sm.) Fresh water.

Valve linear, elliptical; ends produced and slightly capitate; transverse striæ distinct; linear-punctate parallel; longitudinal striæ distinct; intermediate free space very narrow; length ·0040, breadth ·0010. (Plate 31, fig. 35.)

Wm. Sm., B. D., Vol. i., p. 51, Pl. xvii., fig. 144. Ralfs, in Pritch., p. 902, Pl. vii., fig. 62. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 543.—Navicula affinis, var. producta, Rab. Fl. Eur. Alg., sect. i., p. 197.

Botanical Gardens of Trinity College, Dublin. Lower Lake, Killarney, Co. Kerry. Sub-peat Deposit, Dromore, Co. Down.

Navicula cocconeiformis, (Gregory). Fresh water.

Valve elliptical; transverse striæ very fine, linear slightly radiate; longitudinal striæ more obvious; intermediate free space narrow, lanceolate; length ·0016, breadth ·0008. (Plate 31, fig. 36.)

None of the authors I am acquainted with have alluded to the longitudinal striæ, which notwithstanding are very obvious when the valve is observed in a dry state. When mounted in balsam, they are quite undistinguishable, except with very high powers, and with good illumination.

Gregory, Q. J. M. S., 1856, p. 6, Pl. i., fig. 22. Wm. Sm., B. D., Vol. ii., p. 92. Ralfs, in Pritch., p. 896. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 550, T. iv., fig. 9. Rab. Fl. Eur. Alg., sect. 1, fig. 186 and p. 189. Donkin, N. H. Brit. Diat., p. 22, Pl. iii., fig. 11. Lagerstedt, Sötv. Diat. från Spetsbergen och Beeren Eiland, p. 32, T. ii., fig. 8.

Lough Mask, near Toumakeady, Co. Mayo. Lough Mourne deposit.

Navicula Kotschyi, (Grunow). Fresh water.

Valve small, elliptical, lanceolate; ends slightly produced, and occasionally slightly constricted; central nodule large and quadrangular; striæ fine, linear, in the middle more distinct than towards the ends, radiate; longitudinal striæ distinct; length ·0013, breadth ·0005.

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 538, T. iv., fig. 12. This author represents the striæ as moniliform, but in the few forms that came under my notice I could not verify this representation. The longitudinal striæ are not noticed by Grunow, but with careful manipulation they were very apparent in my specimens. Grunow gives three figures of this species; of these the shortest and broadest, and that in which the striæ are not so distinct is the form with which my specimens are most in accordance.—Navicula Kotschyana, Rab. Fl. Eur. Alg., sect. i., p. 193.

Lough Mask, near Tourmakeady, Co. Mayo.

Navicula maxima, (Gregory). Marine.

Frustules on front view slighly constricted in the middle, rounded at the ends; valve linear, ends rounded; transverse striæ fine, linear, parallel; longitudinal striæ two or three; intermediate free space narrow, slightly expanded in the middle; length about ·0050, breadth about ·0011. (Pl. 31, fig. 38.)

Gregory, Q. J. M. S., 1855, p. 41, Pl. iv., fig. 10. Ralfs, in Pritch., p. 909, Pl. vii., fig. 75. Donkin, N. H. Brit. Diat.—The last named author regards this species as identical with Navicula bicuneata, Grunow. There is certainly a strong resemblance between the two forms in many particulars, but nevertheless they seem to me perfectly distinct. Navicula bicuneata is much broader, ever constricted, sometimes very much so, but one longitudinal sulcus is noticeable in it, whereas in Navicula maxima the longitudinal lines are more numerous, and not so distinctly marked. Rab. Fl. Eur. Alg., sect. i., p. 172.

Portmarnock, Ireland's Eye, Co. Dublin. Breaches near Newcastle, Co. Wicklow. Seaweeds, Kilkee. Stomachs of Ascidians, Co. Clare.

Var. linearis, (Grunow). Marine.

Valve much narrower and shorter than the typical form, transverse striæ finer; longitudinal striæ obvious; intermediate free space, narrow, not expanded in the middle; length ·0032; breadth ·0005. (Pl. 31, fig. 39.)

Navicula linearis, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 546, T. iii., fig. 2. Rab. Fl. Eur. Alg., sect. i., p. 180.

Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay. Arran Islands, Co. Galway.

Var. lata, (O'Meara). Marine.

Valves as in the typical form, but relatively shorter and wider, the ends somewhat cuneate; length ·0030; breadth ·0010.

Stomachs of Ascidians, Co. Clare.

Navicula subula, (Kütz.) Marine.

Valve lanceolate, transverse striæ very obscure, longitudinal, obvious; the dry valve pale straw-colour; intermediate free space very narrow; length about ·0024; breadth about ·0004. (Pl. 31, fig. 40.)

Kütz. Bac., p. 91, T. xxx., fig. 19. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 548, T. iii., fig. 24. Rab. Fl. Eur. Alg., sect. i., p. 175. The specimens I have met with are much shorter than that figured by Kützing, and agree with the figure of Grunow.

Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay, Co. Galway. Malahide, Co. Dublin.

Navicula translucida, N. S. Marine.

Valve lanceolate, transverse striæ obvious, costate, radiate; longitudinal striæ, two or three obvious; length, ·0020, breadth, ·0003. (Pl. 31, fig. 41.)

Stomachs of Ascidians, Co. Clare.

Navicula papillifera, N. S. Marine.

Valve elliptical-lanceolate, ends produced, papilliform; median line incurved and expanded towards the central nodule; intermediate free space narrow; transverse striæ obsolete, longitudinal striæ obvious, numerous; length ·0020, breadth ·0006. (Pl. 31, fig. 42.)

Stomachs of Ascidians, Roundstone Bay.

Navicula liburnica, (Grun.) Marine.

Valve elliptical, lanceolate, transverse striæ fine, linear, slightly radiate; longitudinal striæ indistinct, yet with good light noticeable; intermediate free space narrow, lanceolate. (Pl. 31, fig. 43.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 547, T. iii., fig. 25. Rab. Fl. Eur. Alg., sect. i., p. 172.

Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay. Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula plumbicolor, N. S. Marine.

Valve linear, with rounded ends; length, ·0018; breadth, ·0007; transverse striæ very obscure, punctate, radiate, longitudinal sulcus sub-marginal; longitudinal striæ more easily observed than the transverse; intermediate free space narrow, linear; dry valve of a leaden colour. (Pl. 31, fig. 44.)

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula veneta, (Kütz.) Brackish water.

Valve minute; length, ·0010; breadth, ·0003; lanceolate, ends slightly produced; transverse striæ faint, convergent in the middle; longitudinal striæ noticeable with good illumination; longitudinal free space narrow, linear. (Pl. 31, fig. 45.)

Kütz. Bac., p. 95, T. xxx., fig. 76. Donkin (N. H., Brit. Diat., p. 43, Pl. vi., fig. 13,) rightly observes that the form "is abundant in estuaries and harbours between tide marks." Rab. Süssw. Diat., p. 39, T. vi., fig. 83. Ralfs, in Pritch., p. 901. None of the above authors refer to the longitudinal striæ, which, however, by careful illumination may be easily detected if the valves be dry.

Mouth of Bray River, Co. Wicklow. Dollymount Strand, Co. Dublin. Galway Bay, near town of Galway.

Navicula johnsonii, (Wm. Sm.) Marine.

Valve long and narrow ; length, ·0060 ; breath, ·0005 ; inflated in the middle and at the ends ; transverse striæ very fine, parallel, longitudinal striæ more easily detected; colour of dry valve whitish. (Pl. 31, fig. 46.)

Pinnularia johnsonii, Wm. Sm. B. D., Vol. i., p. 58, Pl. xix., fig. 179. Rab. Fl. Eur. Alg., sect. i., p. 211. Rabenhorst considers the form identical with Navicula scopulorum, De Brèbisson. In this opinion he agrees with Ralfs, in Pritch., p. 895, and Donkin, N. H. Brit. Diat., p. 73, Pl. xii., fig. 5. I cannot find any figure of De Brèbisson's species, Navicula scopulorum, and consider the identification of the last named with the present species more than doubtful, inasmuch as Kützing regards that form as identical with Navicula mesotyla, figured by him, Bac., T. v., fig. 3, and T. xxviii., fig. 84. These figures are obscure as to details, but from the size and outline I would think it impossible to confound Navicula johnsonii with them, and therefore I attribute the species to Smith, who has described and figured it with unmistakable accuracy. This course commends itself the more to my judgment, inasmuch as Grunow has described and figured under the name of Navicula scopulorum a form which is obviously distinct from that under consideration.

Bannow, Co. Wexford. Malahide, Portmarnock, Co. Dublin. Mouth of the River Nannywater, Laytown, Co. Meath.

Navicula simulans, (Donkin). Marine.

Valve linear, with long cuneate ends; transverse striæ very faint; longitudinal striæ quite noticeable with good illumination, if the valve be dry; longitudinal free space narrow, except in the middle, where it spreads out to the margin in a narrow stauroform band; length ·0030, breadth ·0006. (Plate 31, fig. 47.)

The present species I consider to be identical with that so named by Donkin, N. H. Brit. Diat., p. 60, Pl. ix, fig. 3. Donkin considers it the same as Amphiprora constricta, Ehr., but in this opinion I cannot concur. Donkin does not notice the longitudinal striæ; but in all other respects the present form is, in my mind, not distinguishable from the species named Navicula simulans by that author.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Malahide, Co. Dublin.

Navicula delginensis, N. S. Marine.

Valve rhomboid, gradually attenuated towards the broadly rounded ends; transverse striæ very faint; longitudinal striæ easily detected, more especially at the margin, where there is a strongly marked sulcus; intermediate free space narrow, lanceolate towards the ends, and slightly expanded in the middle; length ·0020; breadth in the middle ·0006. (Pl. 31, fig. 48.)

This form is in outline very similar to a species described and figured by Grunow as Navicula scopulorum, in Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 547, T. iii. fig. 6. The present species, however, is shorter, broader, and more rhombic; the transverse striæ more obscure, and not reaching the median line, but leaving a distinct intermediate free space.

Seaweeds, Dalkey Island, Malahide, Co. Dublin.

(f) *Crassinerves.*

"*Forms for the most part lanceolate, with very strong median lines and very fine scarcely noticeable structure, in which the longitudinal striæ come out more distinctly than the transverse. These approach the group Limosæ, from which, however, they differ essentially by the colorless condition of the valves in a dry state. In the appearance of the median line there is an approximation to some forms of the group Cuspidatæ not to be mistaken.*"—Grunow.

Navicula rhomboides, (Ehr.) Fresh water.

Valve rhomboid; lanceolate; ends slightly rounded; median line distinct, with two longitudinal lines close to and nearly parallel with it; slightly expanded in the middle, united towards the ends; the median line extending slightly beyond the point of junction; striæ very faint; length about ·0045; breadth about ·0009. (Plate 31, fig. 49.)

With a high objective and very skilful illumination the striæ are found to be parallel. It is noteworthy that in a gathering made by me at Lough Awn, on the summit of the Slieveaneiran Mountain, this form occurred in abundance, for the most part free, but frequently in mucous tubes, ever in single files, and in some cases the frustules were placed end to end, without any mucous investment.

Kütz. Bac., p. 94, T. xxviii., fig. 45; and T. xxx., fig. 44. This author attributes the species to Ehrenberg. Wm. Sm., B. D., vol. i., p. 46, Pl. xvi., fig. 129. Rab. Süssw. Diat., p. 38; T. v., fig. 13. This figure represents the form as much smaller than it is generally found to be. Ralfs, in Pritch., p. 903; Grunow, Verhand. der K. K. Zool. Bot. Gesell, Band x., 1860, p. 549. Donkin, N. H. Brit. Diat., p. 42, Pl. vi., fig. 11. Schumann, Die Diat. der Hohen Tatra., p. 68.

Pool, Glencar, near Glengariff, Bantry, Co. Cork. Lower Lake, Killarney, Arraglen, near Castlegregory, Co. Kerry. Friarstown, Piperstown, Co. Dublin. River Bann, near Coleraine, Co. Derry. Connemara, Co. Galway. Rathdrum, Glenchree, Co. Wicklow. Deposit, Tollymore Park, Co. Down.

Navicula serians, (De Brèb.) Fresh water.

Valve elliptical-lanceolate; ends slightly rounded; median line distinct, as are also the two longitudinal lines, close to and parallel to the same; transverse striæ obscure, slightly oblique; longitudinal striæ distinct; length about ·0038; breadth about ·0009. (Plate 31, fig. 50.)

Kütz. Bac., p. 92; T. xxx., fig. 23; T. xxviii., fig. 43. This author considers the species identical with Frustulia serians, De Brèbisson, and with Navicula lineolata, Ehr. He adds, "I have no doubt that the Ehrenbergian form, which has been described in our T. xxviii., fig. 43, according to Ehrenberg, is perfectly identical with that of De Brèbisson." That form is rather smaller than Navicula serians, and therefore some doubt may reasonably be entertained on the subject. It seems better then, with Donkin, to attribute the species to De Brèbisson than to abandon the specific name by which the species has been so long known. Wm. Sm., B. D., vol. i., p. 47, Pl. 16, fig. 130. Rab. Süssw. Diat., p. 38; T. vi., fig. 51; Ralfs, in Pritch., p. 904. Grunow, Verhand. der K. K. Zool. Bot. Gesell, Band x., 1860, p. 549; T. v., fig. 13. Cleve, Om Svenska och Norska Diat., p. 228. Donkin, N. H. Brit. Diat., p. 41, Pl. vi., fig. 10.

Pool, Cushendun, Co. Antrim. Piperstown, Co. Dublin. Glenchree, Co. Wicklow. Pool near town of Wicklow. Tollymore Park deposit, Co. Down.

Navicula crassinervia, (De Brèb.) Fresh water.

Valve small, elliptical-lanceolate; ends produced and slightly constricted; longitudinal sulci parallel to the median line, distinct; striæ obsolete; length about ·0024; breadth about ·0005. (Plate 31, fig. 51.)

Wm. Sm., B. D., Vol. i., p. 47, Supp. Pl. xxxi., fig. 271, who describes and figures the species according to specimens furnished by De Brèbisson. Ralfs, in Pritch., p. 900. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 548, T. v., fig. 12. Cleve, Om Svenska och Norska Diat., p. 228. Donkin, N. H. Brit. Diat., p. 42, Pl. vi., fig. 12. This last named author considers this species identical with Frustulia saxonica, Rab. Fl. Eur. Alg., sect. i., p. 227.

Friarstown, Piperstown, Featherbed Mountain, Co. Dublin. Lough Gill, Co. Kerry. Bantry, Co. Cork. Rostrevor, Co. Down. Rathdrum, Glencree, Co. Wicklow.

Navicula dirhynchus, (Ehr.) Fresh water.

Valve nearly linear, narrow; ends produced, and slightly capitate. Longitudinal sulci parallel with median line, distinct. Transverse striæ obsolete; longitudinal striæ distinct; length, ·0022, breadth, ·0005. (Plate 31, fig. 52.)

Kützing, Bac., p. 95, T. xxviii., fig. 48, by whom the species is attributed to Ehrenberg. Rab. Süssw. Diat., p. 40, T. vi., fig. 48. Ralfs, in Pritch., p. 901. Donkin, N. H. Brit. Diat., p. 29, Pl. v., fig. 3. The last named author remarks that "in outline this species has a strong resemblance to Navicula affinis, but it is much smaller, and distinguished by the apparent absence of striæ." If the valve be examined in a dry state, the longitudinal striæ are distinct, but much less numerous and distinct than in Navicula affinis; the margin also, instead of being perfectly linear as it is in the last named species, is slightly elliptical.

Lough Mask, near Tourmakeady, Co. Mayo. Featherbed Mountain, Co. Dublin.

Navicula rostellum, (Wm. Sm.) Fresh water.

Valves broadly elliptical; ends produced into very short narrow apices; longitudinal sulci parallel to median line distinct; striæ obscure; length ·0020; breadth ·0010. (Plate 31, fig. 53.)

Wm. Sm., B. D., Vol. ii., p. 93. Ralfs, in Pritch., p. 900. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 550, T. iv., fig. 10. This form, as described by Grunow, is narrower, and the apices much wider than in my specimens; the transverse striæ as described, are very fine and parallel, but as my specimens were mounted in balsam, I could not detect the striæ. Donkin, N. H. Brit. Diat., p. 40, Pl. vi., fig. 7. Rab. Fl. Eur. Alg., sect. i., p. 195. The last named author describes the striæ as very delicate and parallel.—Navicula apiculata, Gregory Q. J. M. S., Vol. iv., 1856, Pl. i., fig. 13, who attributes the form to Wm. Smith.

Killakee, Co. Dublin.

Navicula lævissima, (Kütz.) Fresh water.

Valve colourless, slightly expanded in middle, slightly constricted towards the broad rounded ends; median line strongly developed; transverse striæ very fine, slightly radiate; longitudinal striæ distinct; intermediate free space narrow, except in the middle, where sometimes it seems to expand in a short narrow stauroform band; at the extreme end a distinct transverse line is noticeable at right angles with the median line; length ·0015, breadth ·0004. (Plate 31, fig. 54.)

Kütz. Bac. p. 96, T. xxi., fig. 14. Wm. Sm., B. D., Vol. ii., p. 91. Grunow, Verhand. der K. K., Zool. Bot. Gesell., Band x., 1860, p. 549, T. iv., fig. 5. Rab. Fl. Eur. Alg., sect. i., p. 188. Donkin, N. H. Brit. Diat., p. 28, Pl. v., fig. 2.

Lower Lake, Killarney, Co. Kerry. Derrylane Lough, Co. Cavan. Lough Neagh, near Antrim town. Ulster Canal, near Poyntzpass, Co. Armagh. Loughbrickland Lake, Co. Down. River Bann, near Coleraine, Co. Derry. Trinity College Botanic Gardens, Co. Dublin. Killeshin, Queen's Co. Feighcullen, Co. Kildare.

Navicula oblongella, (Naegeli?) Fresh water.

Valve small, linear, elliptical; ends rounded; longitudinal sulci close to median line, strongly developed, parallel; transverse striæ fine, but easily detected, parallel; longitudinal striæ generally obscure; intermediate free space narrow, except in the middle, where it expands into a quadrangular area; length about ·0008, breadth about ·0008. (Plate 31, fig. 55.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell, Band x., 1860, T. iv., fig. 4. Grunow, with a note of doubtfulness, refers the species to Naegeli. Schumann, Die Diat. der Hohen Tatra, p. 70. Rab. Fl. Eur. Alg., sect. 1, p. 185.

Lough Derg, Co. Galway. Killakee, Co. Dublin. Ditch near town of Galway.

Navicula incurva, (Greg.) Fresh water.

Valve slightly incurved in the middle; ends broadly produced, subcapitate; longitudinal sulci parallel, with median line distinct; striæ obscure; length about ·0020, breadth ·0005. (Plate 31, fig. 56.)

Gregory, Q. J. M. S. 1856, p. 8, Pl. i., fig. 26. Ralfs, in Pritch., p. 893. Rab. Fl. Eur. Alg., sect. i., p. 203. Donkin, N. H. Brit. Diat., p. 38, Pl. vi., fig. 2.

Portmarnock, Co. Dublin. Callows, near Ballinasloe, Co. Galway.

(g) *Moniliferæ.*

Valves more or less lanceolate; striæ obviously moniliform, not reaching the median line; free intermediate space narrow except in the middle, where it is generally more or less expanded.

Navicula punctulata, (Wm. Smith.) Brackish or marine.

Valve broadly elliptical, with slightly apiculate ends; intermediate free space narrow, slightly expanded in the middle; striæ close, radiate; length about ·0026, breadth ·0012. (Plate 32, fig. 1.)

Wm. Sm., B.D., vol. i., p. 52, Pl. xvi., fig. 151. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 537.—Navicula marina, Ralfs, in Pritch., p. 903. Rab. Fl. Eur. Alg., sect. i., p. 202. Donkin, N. H. Brit. Diat., p. 19, Pl. iii., fig. 5. The last named author remarks, "Although this species is described as marine in the Synopsis of Prof. Smith, I have never found it in purely marine localities, where its congener N. granulata is found." Some of the undernamed localities in which I have found the species are decidedly marine.

Stomachs of Ascidians, Belfast Lough, Co. Antrim. Seaweeds, Bannow, Co. Wexford. Portmarnock, Co. Dublin. Rostrevor, Co. Down. Seaweeds, Kilkee, Co. Clare. Laytown, Co. Meath. Drehednamaud, near Castlegregory, Co. Kerry.

Navicula granulata, (De Brèbisson). Marine.

Valve broadly elliptical, with slightly produced broad rounded ends; intermediate free space narrow, linear, except at the centre, where it expands considerably; expanded area somewhat rounded; striæ moniliform, convergent in the middle, then strongly radiate; length ·0035; breadth ·0017. (Plate 32, fig. 2.)

Donkin, Q. J. M. S., 1858, p. 17, Pl. iii., fig. 19, who attributes the species to De Brèbisson. Ralfs, in Pritch., p. 903. Cleve, Om Svenska och Norska Diat., p. 226. Rab. Fl. Eur. Alg., sect. i., p. 201. Donkin, N. H. Brit. Diat., p. 17, Pl. iii., fig. 1.

Drehednamaud, near Castlegregory, Co. Kerry. Stomachs of Ascidians, Roundstone Bay, Stomachs of Ascidians, Broadhaven Bay, Galway Bay, Co. Galway.

Navicula humerosa, (De Brèbisson.) Marine.

Valve linear, elliptical, gradually contracted towards the broad, produced, rounded ends; slightly constricted in the middle; striæ close, moniliform; puncta small, convergent in the middle, radiate towards the ends; intermediate free space narrow, except in the middle, where it is broadly and somewhat roundly expanded; length, about ·0032, breadth, about ·0013, and in middle about ·9012. (Plate 32, fig. 3.)

Wm. Smith, (B. D., Vol. ii., p. 93), who attributes the species to De Brébisson. Ralfs, in Pritch., p. 903. Rab. Fl. Eur. Alg., sect. i., p. 201.

Bannow, River Slaney, near Killurin. Co. Wexford. Portmarnock, Malahide, Co. Dublin. Seaweeds, Portrush, Co. Antrim. Caum Lough, near Tralee, Lough Gill, Co. Kerry. Kilkee, Co. Clare. Salt marsh, Kilcool, Co. Wicklow.

Var. fuscata, (Schumann). Marine.

Like the typical form, but having the ends slightly capitate, and the margins perfectly linear; length ·0038, breadth ·0014. (Plate 32, fig. 4.)

Likely the same as Navicula fuscata, Schumann, Die Preussische Diat., p. 57, T. ii., fig. 43.

Drehidnamaud, near Castlegregory: Lough Gill, Co. Kerry. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. quadrata, (Gregory). Marine.

Like the typical form, but much shorter and relatively broader; the margins linear; the ends, too, being broader and less produced; length ·0020, breadth ·0012. (Plate 32, fig. 5.)

Navicula quadrata, Gregory, Q. J. M. S., 1856, p. 41, Pl. v., fig. 5. Donkin (N. H. Brit. Diat., p. 18) considers this identical with Navicula humerosa, and Ralfs adopts the same opinion in Pritchard, p. 903.

Lough Gill, Co. Kerry. Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Seaweeds, Portrush, Co. Antrim.

Navicula latissima, (Gregory). Marine.

Valve large, broadly elliptical; ends slightly produced, rounded; intermediate free space broad, lanceolate, greatly expanded around the central nodule; striæ linear, with moniliform striæ interposed, convergent in the middle, radiate towards the ends; length ·0060, breadth ·0032. (Plate 32, fig. 6.)

Gregory, Q. J. M. S., 1856, p. 40, Pl. v., fig. 4. Ralfs, in Pritch., p: 903, Pl. vii., fig. 70. Rab. Fl. Eur. Alg., sect. i., p. 201. Donkin, N. H. Brit. Diat., p. 17, Pl. iii., fig. 2.—Pinnularia divaricata, O'Meara, Q. J. M. S., 1867, p. 116, Pl. v., fig. 7.

Arran Islands, Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula meniscus, (Schumann). Fresh water.

Valve broadly elliptical; ends slightly produced, not capitate; intermediate free space narrow, except in the middle, where it expands into a large stauroform band, wider towards the margin than at the central nodule; striæ linear, with moniliform striæ interposed, convergent in the middle, radiate towards the ends; length ·0026, breadth ·0013. (Plate 32, fig. 7.)

Schumann, Die Preussische Diat., p. 55, T. ii., fig. 32. Schumann's account of the locality in which the form was found by him leaves some doubt as to whether the deposit in which the form was discovered was marine or fresh water; his words are: "In deposito Regimontano, in portu Pillawensi, in Mari Baltico. Lagerstedt, however, includes the form among fresh-water species, under the name of Navicula punctata, var. asymmetrica, Sötvat. Diat. frän Spetsbergen, p. 29, T. ii., fig. 7." This figure so precisely corresponds in all respects with the form here described, as to render the identity perfectly certain. Lagerstedt states that the frustule on front view is slightly unsymmetrical on the longitudinal axis. This seems to me to have been accidental, arising perhaps from the valves having been separated at one end while adhering at the other; he adds, "only a single specimen of this variety was found." And I have precisely the same report to make. So distinct is this form in its leading characters that I consider it a perfectly independent species, and not to be regarded as a variety of Navicula punctata.

Pond near the city of Armagh.

Navicula lucida, N. S. Marine.

Valve broadly elliptical, with sub-lanceolate ends; intermediate free space lanceolate, narrow, except in the middle, where it expands considerably; a strongly marked submarginal sulcus is present; striæ moniliform; puncta very close; convergent in the middle; divergently radiate towards the apices; length ·0020; breadth ·0012. (Plate 32, fig. 8.)

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula cluthensis, (Gregory). Marine.

Valve broadly elliptical, with rounded ends; intermediate free space narrow, linear, but slightly expanded at the central nodule; striæ moniliform; puncta small, close, nearly parallel in the middle, and divergently radiate towards the ends; length, ·0020; breadth, ·0013. (Plate 32, fig. 9.)

Gregory, Diat. of Clyde, p. 478, Pl. ix., fig. 2. Ralfs, in Pritch., p. 909, Pl. vii., fig. 73. Rab. Fl. Eur. Alg., p. 184.—Navicula erythræa, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 539, T. v., fig. 17.

River Slaney, near Killurin, Co. Wexford. Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. producta, (O'Meara). Marine.

Precisely as the typical species, but having the ends slightly produced; length ·0025, breadth ·0011. (Plate 32, fig. 9a.)

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula punctata, (Kütz.) Fresh water.

Valve elliptical, ends produced, narrow, capitate; intermediate free space narrow, except in middle, where it expands into a tolerably broad stauroform band, widening towards the outer end; striæ moniliform; puncta small; radiate; length ·0032, breadth ·0010. (Plate 32, fig. 10.)

Donkin, N. H. Brit. Diat., p. 36, Pl. v., fig. 12. Lagerstedt, Sötvat. Diat. frän Spetsberger och Beeren Eiland, p. 29.—Stauroneis punctata, Kütz., Bac., p. 100, T. xxi., fig. 9. Wm. Sm., B. D., Vol. i., p. 61, Pl. xix., fig. 189. Ralfs, in Pritch., p. 912. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 565. Castracane, Catalogo di Diat. raccolte nella Val Intrasca, p. 11. Cleve, Om Svenska och Norska Diat., p. 228. Rab. Fl. Eur., Alg., sect. i., p. 245.—Stauroptera punctata, Rab. Süssw. Diat., p. 50, T. ix., fig. 11.

River Slaney, near Killurin, Co. Wexford. Drumoughty Lough, near Kenmare, Lower Lake, Killarney, Lough Gill, Co. Kerry. Lough Mask, near Tourmakeady, Co. Mayo. Lough Mourne deposit, Co. Antrim.

Navicula lacustris, (Gregory). Fresh water.

Similar to Navicula punctata, but the striæ are very much finer; and the intermediate free space expanded roundly, instead of in a stauroform band; length about ·0020, breadth ·0006. (Plate 32, fig. 11.)

Gregory, (Q. J. M. S., 1856, p. 6, Pl. i., fig. 23.) describes two distinct varieties, one elliptical, the other with linear margin and produced ends. He also refers to an intermediate form, which latter, I presume, to be the present one. Ralfs, (in Pritch., p. 903), says the only species with which this could be confounded is Navicula firma, but it appears to me that it is more likely to be confounded with Navicula punctata. Rab. Fl. Eur. Alg., sect. i., p. 200.

Lough Mask, near Tourmakeady, Co. Mayo. Lough Neagh, near the town of Antrim. Lough Gill, Lower Lake, Killarney, Pedlass Lake, near Dingle, Co. Kerry.

Navicula maculosa, (Donkin). Marine.

Valve linear, elliptical; ends slightly produced and somewhat cuneate; intermediate free space linear, narrow, slightly expanded around the central nodule; striæ distinctly moniliform, parallel in the middle, and divergently radiate towards the ends; length ·0027, breadth ·0008. (Plate 32, fig. 12.)

Donkin, N. H. Brit. Diat., p. 25, Pl. v., fig. 1.

Piles of wooden bridge, Dollymount Strand, Co. Dublin.

Navicula scutelloides, (Wm. Sm.) Fresh water.

Valve nearly orbicular, minute; intermediate free space narrow, linear, slightly expanded in the middle; striæ distant, moniliform, divergently radiate; length, ·0009; breadth, ·0008. (Plate 32, fig. 13.)

Wm. Sm., B. D., Vol. ii., p. 91. Grunow, (Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 533, T. v., fig. 15), places it in intimate connexion with Navicula lyra and Navicula hennedyi, but the position I assign to it seems to me more appropriate. Rafls, in Pritch., p. 909. Rab. Fl. Eur. Alg., sect. i., p. 185.

Lough Neagh, near Antrim. Lough Mask, near Tourmakeady, Co Mayo.

Navicula pusilla, (Wm. Sm.) Brackish water.

Valve small, broadly elliptical, ends produced; narrow, rounded; intermediate free space narrow, linear, expanded in the middle; striæ distinctly moniliform; convergent in the middle, and radiate towards the ends; more distant in the middle, closer towards the ends; length ·0015; breadth, ·0008. (Plate 32, fig. 14.)

Wm. Sm., B. D., Vol. i., p. 52, Pl. xvii., fig. 145. Ralfs, in Pritch., p. 900. Cleve, Om Svenska och Norska Diat., p. 227. It is likely that the form mentioned by Cleve may be a distinct species, as he attributes it to fresh water. Rab. Fl. Eur. sect. i., p. 193. Donkin, N. H. Brit. Diat., p. 20, Pl. iii., fig. 6.—Navicula tumida, var. subsalsa, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 537, T. iv., fig. 43.

Brackish ditch near town of Wexford; Tacumshane, Co. Wexford. Ballysodare, Co. Sligo. Breaches near Newcastle, Co. Wicklow.

Lough Gill, Co. Kerry, River Bann, near Coleraine; Bellarena, Co. Derry. Brackish ditches near town of Galway. Portmarnock, Co. Dublin.

Var. lanceolata, (Grunow). Marine or brackish water.

Valve lanceolate, ends produced; relatively longer and narrower than the typical species. Length ·0024, breadth ·0008.

Navicula tumida, var. lanceolata, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 537, T. iv. fig. 44. This as well as the preceding species, being both incidental to marine or brackish water, can scarcely be regarded as varieties of Navicula tumida, which is a fresh water species.

Portmarnock, Co. Dublin. Breaches near Newcastle, Co. Wicklow.

Navicula tumida, (Wm. Sm.) Fresh water.

Valve small, elliptical, with short capitate ends; intermediate free space narrow, slightly expanded in the middle; striæ close, moniliform; convergent in the middle, and radiate towards the ends; length varying from ·0013 to ·0020; breadth from ·0005 to ·0008.

Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 146. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 537, T. iv., fig. 43*a*. Cleve, Om Svenska och Norska Diat., p. 226.—Navicula Anglica, Ralfs, in Pritch., p. 900. Rab. Fl. Eur. Alg., sect. i., p. 193. Donkin, N. H. Brit. Diat., p. 35, Pl. v., fig. 11*a*.

Kilcool; streamlet in Powerscourt demesne, Co. Wicklow. Lough Mask, Tourmakeady, Co. Mayo. Ditch near town of Sligo.

Var. linearis, (O'Meara). Fresh water.

Similar to the typical form, but sides linear, ends slightly produced; striæ coarser, obviously moniliform, radiate; length ·0011, breadth ·0005. (Plate 32, fig. 15.)

Lough Gill, Co. Kerry. Lough Mask, Tourmakeady, Co. Mayo.

Navicula pulchra, (Gregory). Marine.

Valve lanceolate; intermediate free space narrow, expanded in the middle; striæ distinctly moniliform, radiate; length ·0027, breadth ·0008. (Plate 32, fig. 16.)

Gregory, Q. J. M. S., 1856, Trans., p. 42, Pl. v., fig. 7. Ralfs, in Pritch., p. 906. Rab. Fl. Eur. Alg., sect. i., p. 176.

Galway Bay near the town of Galway.

(h) *Fuscatæ.*

Valves more or less elliptical; striæ divided into two portions on each side of the median line, by two longitudinal sulci, forming a tolerably broad rhomboidal space about the median line.

Navicula fusca, (Gregory). Marine.

Valve oblong elliptical; striæ obviously moniliform, radiate; intermediate space lanceolate, divided into three compartments, one unstriate, and having the median line in the centre, and one on either side striate; central nodule large; length about ·0047, breadth about ·0022. (Plate 32, fig. 17.)

Ralfs, in Pritch., p. 898; Rab. Fl. Eur. Alg., sect. i., p. 179. Donkin, N. H. Brit. Diat., p. 7, Pl. i., fig. 5.—Navicula Smithii var. fusca, Gregory, Diat. of Clyde, p. 486, Pl. ix., fig. 15. Schmidt's Atlas der Diat., T. vii., fig. 1.

Arran Islands; stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven, Co. Galway. Rostrevor, Co. Down.

Navicula smithii, (De Breb.) Marine.

Valve broadly elliptical; striæ moniliform, slightly radiate; intermediate space narrow, lanceolate, consisting of three distinct portions, one unstriate about the median line, and one on either side of the latter striate; length about ·0027, breadth about ·0012. (Plate 32, fig. 18.)

Wm. Sm., B. D., Vol. ii., p. 92. Smith assents to the suggestion of De Brèbisson, to change to Navicula smithii the form he had previously named Navicula elliptica, B. D., Vol.i., p. 48, Pl. xvii., fig. 152. For this reason Grunow, Heiberg, and Donkin rightly attribute the species to De Brèbisson. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 531. Heiberg, De Danske Diat., p. 81. Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg., sect. i., p. 178. Donkin, N. H. Brit. Diat., p. 6, Pl. i., fig. 4. Schmidt's Atlas der Diat., T. vii., fig. 16.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Rostrevor, Dundrum Bay, Co. Down. Bannow, Co. Wexford. Seaweeds, Kilcool, Co. Wicklow.

Var. subrotunda, (O'Meara). Marine.

Like the typical species, but nearly orbicular.

Schmidt's Atlas der Diat., T. vii., fig. 17, fig. 22?

Stomachs of Ascidians, Roundstone Bay; Arran Islands, Co. Galway.

Var. rhombica, (O'Meara). Marine.

Valve like that of the typical form in general structure, but differing in its distinctly rhombic outline, as well as in the rhombic form of the inner band of striæ.

A form which seems to me to be identical with this is described by Schmidt, Atlas der Diat., T. vii., fig. 18.

Arran Islands, Co. Galway.

Navicula collisiana, N. S. Marine.

Valve broadly elliptical. Nearly linear at the margin, with broadly rounded ends. Intermediate space wide, oblong, elliptical. Striæ costate. Marginal striate band wide, striæ distinctly moniliform, nearly parallel in the middle; more and more radiate towards the ends; length ·0026, breadth ·0016. (Plate 32, fig. 19.)

This form is distinguished from Navicula fusca, and Navicula smithii, which in other respects it strongly resembles, by the broad oblong elliptical outline of the inner striate band, and more specially by the fact that the striæ in this portion of the valve are distinctly costate, while in the others they are moniliform. It was first exhibited by me at a meeting of the Dublin Microscopical Club, some years since, at the house of the late Surgeon Maurice Collis.

Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway. Kilcool, Co. Wicklow.

Navicula æstiva, (Donkin). Marine.

Valve linear, elliptical; striæ fine, obscurely moniliform, parallel in the middle, slightly radiate towards the ends; inner striate band narrow, elliptical; length about ·0022; breadth about ·0010. The distinctive character of this species is the fineness of the striæ. (Plate 32, fig. 20.)

Donkin, Q. J. M. S. Trans., 1858, p. 32, Pl. iii., fig. 18; and N. H. Brit. Diat., p. 6, Pl. i., fig. 3. Donkin's figures represent the species as much larger than my specimens would lead me to regard it. Ralfs, in Pritch., p. 899. Rab. Fl. Eur. Alg., sect. i., p. 184.

Arran Islands, Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula elliptica, (Kütz.) Fresh water.

Valve elliptical; striæ of the marginal band distinctly moniliform, converging in the middle, radiate towards the ends; inner striate band very narrow; free space about the median line greatly expanded, forming a rounded rhombic outline; median line strongly developed; length about ·0020, breadth about ·0011. (Plate 32, fig. 21.)

Kütz. Bac., p. 98, T. xxx., fig. 55. Wm Sm., B. D., Vol. ii., p. 92. Ralfs, in Pritch., p. 899. Rab. Fl. Eur. Alg., sect. i., p. 179.

Donkin, N. H. Brit. Diat., p. 7, Pl. i. fig. 6. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 531. Heiberg, De Danske Diat., p. 81. Cleve, Om Svenska och Norska Diat, p. 226. Schumann, Die Diat. der Hohen Tatra., p. 69. Lagerstedt, Sötvat. Diat. frän Spetsbergen och Beeren Eiland, p. 27. Schmidt, Atlas der Diat., T. vii. figs. 31, 32.—Navicula ovalis, Wm. Sm., B. D., Vol. i., p. 48, Pl. xvii., fig. 153*a*.

Tacumshane, Co. Wexford. Lower Lake, Killarney, Co. Kerry. Glenchree, Powerscourt, Co. Wicklow. Lucan, Killakee, Bohernabrena, Co. Dublin. Feighcullen, Royal Canal, near Enfield, Co. Kildare. Pond, near the city of Armagh.

Var. costata, (O'Meara). Fresh, or brackish water.

Valve strongly resembling the typical species, but striæ distinctly costate, and intermediate free space included between the inner margins of the inner striate band lanceolate, but slightly expanded in the middle.

This variety has been found in localities where marine and fresh water forms are mixed.

Breaches near Newcastle, Co. Wicklow. Lough Gill, Co. Kerry.

Var. davidsonii, (O'Meara). Fresh water.

Valve ovate-elliptical. Striæ very fine, moniliform; space included within the inner margin of the inner striate band linear, roundly expanded in the middle.

This variety was first brought under my notice by my valued correspondent, Rev. George Davidson, of Logie, Coldstone, near Aberdeen, who found it in his neighbourhood. It has since been noticed by me in various localities in Ireland. On first view this form would seem to belong to Navicula æstiva, and when first noticed by me in a fresh water gathering, I considered it was a stray form of the species mentioned, which had come there by accident; but subsequent observation induced me to give up this view, and to consider the form a well marked variety. It is likely the same as that figured by Schmidt in his Atlas der Diat., T. vii., fig. 33.

Moist Rock. Portrush, Co. Antrim, Lough Mask, near Tourmakeady, Lough Neagh, near Lurgan, Co. Armagh.

Var. ovalis, (Wm. Smith). Fresh water.

Valve linear, oblong, with rounded ends; striæ much finer than in the case of the typical form; length about ·0016, breadth about ·0005. (Plate 32, fig. 22.)

Navicula ovalis, Wm. Sm., B. D., Vol. i., p. 48, Pl. xvii., fig. 153 *a*. Under the impression that this form and Navicula elliptica were identical, Smith abandoned the specific name of ovalis, and merged the two forms under the one designation Navicula elliptica. However close the resemblance must be acknowledged to be, there is such a difference in the details of structure as to require notice. Ralfs, in Pritch., p. 899, regards the form as identical with Navicula elliptica, and the same view is adopted by the following authors: Cleve, Om Svenska och Norska Diat., p. 226. Rabenhorst, Fl. Eur. Alg., sect. i., p. 179. Donkin, N. H. Brit. Diat. Lagerstedt, Sötvat. Diat. frän Spetsbergen och Beeren Eiland, p. 27, and probably Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 531. Castracane includes the two forms under the designation of Navicula ovalis; Catalogo di Diat. raccolte nella Val. Intrasca, p. 12. Schmidt, treating the two forms as distinct species, describes the present as Navicula ovalis; Atlas der Diat. T. vii., figs. 34 and 35.

Camolin, Co. Wexford. Lough Neagh, near Lurgan, Co. Armagh. Lough Gill, Co. Kerry. Lough Mourne deposit.

Var. parva, (O'Meara). Fresh water.
Valve like the last variety, but very much smaller, and the striation extremely indistinct; length ·0008, breadth ·0004.
It seems not improbable that this variety is identical with that described as Navicula oblongella by Schmidt, Atlas der Diat., T. vii., fig. 53.

Camolin, Co. Wexford.

(i) *Clavatæ.*

Valves elliptical; striæ in two distinct bands, one marginal, another close to the median line, with a wide elliptical intervening space. Marginal band of striæ lunate on the inner margin.

Navicula clavata, (Gregory). Marine.
Valve broadly elliptical; ends broadly produced and rounded; striæ moniliform, marginal band broad, narrowing towards the ends; inner bands of striæ separated from the median line by a narrow unstriate space, bending outward near the central nodule, where they terminate sharply, making a wide free space about the central nodule; space intervening between the inner and outer bands of striæ unstriate, broad and lunate; length about ·0050, breadth about ·0026. (Plate 32, fig. 23.)
Gregory, Q. J. M. S. Trans. 1856, p. 46, Pl. v., fig. 17. Ralfs, in Pritch., p. 898. Donkin, N. H. Brit. Diat., p. 15, Pl. ii., fig. 8.—Navicula lyra, Rab. Fl. Eur. Alg., sect. i., p. 178.

Stomachs of Ascidians, Co. Clare. Stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven Bay, Arran Islands, Co. Galway.

Navicula hennedyi, (Wm. Sm.) Marine.

Valve broadly elliptical, ends not produced; striæ moniliform; inner and outward bands of striæ, narrower than in Navicula clavata, but in other respects very similar; length about ·0030, breadth about ·0020. (Plate 32, fig. 24.)

Wm. Sm., B. D., Vol. ii., p. 93. Gregory, Q. J. M. S. Trans., 1856, p. 40, Pl. v., fig. 3. Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg. sect. i., p. 178. Donkin, N. H. Brit. Diat., p. 11, Pl. ii., fig. 3. Schmidt, Atlas der Diat., T. iii., figs. 17, 18.

Stomachs of Ascidians, Belfast Lough, Co. Antrim. Stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven Bay, Arran Islands, Co. Galway.

Navicula nebulosa, (Gregory). Marine.

Valves in outward form similar to those of Navicula hennedyi, but narrower; the space intervening between the outer and inner bands of striæ obscurely marked with very fine parallel lines of puncta, which do not extend throughout; length about ·0042, breadth about ·0020. (Plate 32, fig. 25.)

Gregory, Diat. of Clyde, p. 480, Pl. ix., fig. 8. Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg. sect. i., p. 179. Donkin, N. H. Brit. Diat., p. 11, Pl. ii., fig. 2. Schmidt, Atlas der Diat., T. iii., fig. 14. The clouded appearance of the space intervening between the inner and outer bands of striæ, as represented in the figures of Gregory and Donkin, is found with good illumination to arise from the fine punctate striæ above referred to.

Stomachs of Ascidians, Roundstone Bay, Arran Islands, Co. Galway.

Var. suborbicularis, (O'Meara). Marine.

Valve shorter and relatively broader than that of the typical species; marginal band of striæ relatively broader; that next the median line relatively narrower; intermediate space between the inner and outer bands of striæ narrow, and occupied by irregularly disposed puncta; length ·0024, breadth ·0014. (Plate 32, fig. 26.)

Arran Islands, Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula prætexta, (Ehr.) Marine.

Valve broadly elliptical; marginal band of striæ broad, distinctly moniliform; median bands of striæ broad, distinctly moniliform; intermediate space between the outer and inner bands of striæ ornamented with irregularly arranged large, round puncta; free unstriate space between the median line and the inner margins of the inner band of striæ expanding in the middle, with a narrow stauroform band; length about ·0040, breadth about ·0025. (Plate 32, fig. 27.)

Ehrenberg, in Proceedings of Berlin Acad., 1840, p. 20. Kütz.

Bac., p. 98. Gregory, Diat. of Clyde, p. 481, Pl. ix., fig. 11. Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg. sect. i., p. 183. Donkin, N. H. Brit. Diat., p. 10, Pl. ii., fig. 1. Schmidt, Atlas der Diat., T. iii., fig. 31.

Arran Islands, Stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula moreii, N. Sp. Marine.

Valve very large, broadly elliptical, somewhat rhombical; marginal band of striæ broad in the middle, diminishing towards the ends; median band of striæ narrow, terminating considerably short of the central nodule; intermediate space between the inner and outer bands of striæ broad, unstriate; striæ fine, but distinctly moniliform; nearly parallel in the middle, slightly radiate towards the ends; length ·0075, breadth ·0037. (Plate 32, fig. 28.)

Navicula kittoniana, Schmidt, Atlas der Diat., T. ii., fig. 10. The form having been exhibited by me some years ago at the Meeting of the Dublin Microscopical Club, under the name of Navicula moreii, the latter designation has the priority. Schmidt's locality is Rio Janeiro.

Stomachs of Ascidians, Broadhaven Bay; stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula sandriana, (Grunow). Marine.

Valve nearly orbicular; marginal band of striæ narrow, of equal breadth till near the ends, where it widens, and then suddenly narrows; median band of striæ very narrow, not reaching the median line, and terminating at some distance from the central nodule; intermediate space between the inner and outer bands of striæ wide, ornamented with irregularly disposed indistinct puncta, and having in the middle a narrow, longitudinal lunate band of small, but distinct, puncta; striæ of the marginal band moniliform, radiate; striæ of the inner band punctate, and parallel; length about ·0040, breadth about ·0030. (Plate 32, fig. 29.)

This form was exhibited by me at a Meeting of the Dublin Microscopical Club as Navicula cœlata, but subsequently I discovered that the species had been described in 1863 by Grunow as Navicula sandriana, which designation, having the priority, must be permitted to stand.

Grunow, Verhand. der K. Zool. Bot. Gesell., Band xii., 1863, p. 153, T. iv., fig. 5. Schmidt, Atlas der Diat., T. iii., fig. 10. Grunow's locality for the species is the Adriatic Sea. I may here remark that my specimens differ from those figured by Grunow and Schmidt, by the fact that in mine the outer band of striæ expands perceptibly near the ends, a feature which is not noticeable in the figures referred to above.

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula franciscæ, N. S. Marine.

Valve nearly orbicular; marginal band of striæ narrow; median band of striæ narrow, distant from median line, leaving a lanceolate, unstriate space between the inner margins; intermediate space between the inner and outer bands of striæ broad, unstriate; striæ moniliform, parallel in the middle, radiate towards the ends; length ·0033, breadth ·0030. (Plate 32, fig. 30.)

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula hibernica, N. S. Marine.

Valve elliptical oblong; marginal band of striæ narrow, slightly broader in the middle than at the ends; inner band of striæ narrow, roundly expanded at the ends; intermediate space between the inner and outer bands of striæ broad, ornamented with irregularly disposed distinct puncta; striæ of the marginal band linear, with moniliform striæ interposed, parallel in the middle, radiate towards the ends; striæ of the inner band punctate, parallel. (Plate 32, fig. 31.)

Stomachs of Ascidians, Roundstone Bay; Arran Islands, Co. Galway.

Navicula nitescens. (Gregory). Marine.

Valve elliptical, lanceolate; striæ apparently strongly costate, divided by a longitudinal sulcus into two nearly equal compartments; free space between the inner margins of the inner bands of striæ narrow, lanceolate; slightly expanded in the middle. (Plate 32, fig. 32.)

Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg. sect. i., p. 179. Donkin, N. H. Brit. Diat., p. 8, Pl. i. fig. 7.—Navicula smithii, var. nitescens, Gregory, Diat. of Clyde, p. 487, Pl. ix., fig. 16.—Pinnularia arraniensis, O'Meara, Q. J. M. S., 1867, p. 116, Pl. v., fig. 6.

Arran Islands. Stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula richardsoniana, N. S. Marine.

Valve narrow, elliptical; ends rounded; inner band of striæ broad outer band of striæ very narrow; striæ strongly costate, sub-distant, radiate; length ·0024, breadth ·0006. (Plate 32, fig. 33.)

This form strongly resembles Navicula nitescens, but differs so much as to be entitled to be regarded as a distinct species.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula stokesiana, N. S. Marine.

Valve large, rhombic, lanceolate; marginal striate band wide; inner striate band narrow, elevated above the surface; free space included within the inner margins of the inner striate bands narrow, linear, forming in the middle a very narrow stauroform line; space intermediate between the outer and inner striate bands occupied by lines of striæ, which are prolongations of the striæ of the marginal band; striæ close, punctate, radiate; length ·0045, greatest breadth ·0018.

This form is one of very rare occurrence, only three specimens having been noticed. The only forms I have seen figured which bear resemblance to this very striking species are those of Mastogloia jelinickiana, Grunow, Reise S. M. Novara um die Erde, T. i. A., fig. 11; and Navicula irrorata, Schmidt, Atlas der Diat., T. ii., fig. 19. As to the former, even a cursory examination suffices to show that this form is perfectly distinct. As to the latter, the inner and outer bands of striæ are separated by an intervening blank space, whereas in the present case the corresponding intermediate space is distinctly striate.

This beautiful species I wish to identify with the name of the present respected President of the Royal Irish Academy. (Plate 32, fig. 34.)

Stomachs of Ascidians, Roundstone Bay; stomachs of Ascidians, Broadhaven Bay, Co. Galway.

(j) *Lyratæ.*

Similar to the last sub-group, and distinguished by the bending in at the middle of the marginal striate band, which consequently is bilunate on the inner margin. The intermediate free space is more or less distinctly lyrate.

Navicula wrightii, (O'Meara). Marine.

Valve linear elliptical; ends broadly produced; marginal band of striæ tolerably wide, projecting inwards slightly in the middle; striæ moniliform, nearly parallel at the middle, slightly radiate towards the ends; inner band of striæ narrow, expanded at the ends; intermediate space between the inner and outer bands of striæ wide, unstriate; length ·0045, breadth ·0018. (Pl. 32, fig. 35.)

Navicula wrightii, var. Q. J. M. S., 1867, p. 116, Pl. v., fig. 46.—Navicula caribea, Schmidt, Atlas, T. ii., fig. 17.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula spectabilis, (Gregory). Marine.

Valve broadly elliptical; marginal band of striæ broad in the middle, and gradually decreasing towards the ends; inner band of striæ wide; striæ moniliform, nearly parallel in the middle, slightly radiate towards the ends; intermediate space between the inner and outer bands of striæ very wide, unstriate, but interrupted by a narrow longitudinal nebulous belt, which runs conformably with the inner edge of the marginal band of striæ; length ·0044, breadth ·0025.

Gregory, Diat. of Clyde, p. 481, Pl. ix., fig. 10. Ralfs, in Pritch., p. 898. Rab. Fl. Eur. Alg., sect. i., p. 178. Donkin, N. H. Brit. Diat., p. 12, Pl. ii., fig. 5. Cleve, Om Svenska och Norska Diat., p. 226.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Var. sub-orbicularis, (O'Meara). Marine.

In all respects resembling the typical species, but nearly orbicular; the marginal band of striæ relatively broader, the inner band of striæ; as well as the intermediate space between the inner and outer striate bands much narrower; length ·0024, breadth ·0018. (Plate 32, fig. 36.)

Navicula spectabilis, var.? Schmidt, Atlas der Diat., T. ii. fig. 31.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula lyra, (Ehr.) Marine.

Valve linear elliptical; ends broadly produced; marginal band of striæ broad; inner band broad, incurved in the middle; intermediate free space between the inner and outer bands of striæ very narrow; ends pointed and directed outwards; striæ moniliform; length, about ·0040, breadth, about ·0014. (Plate 33, fig. 1.)

Kützing, Bac., p. 94, T. xxviii., fig. 55, who refers the species to Ehrenberg. Gregory, Diat. of Clyde, p. 485, Pl. ix., fig. 13*b*. Ralfs, in Pritch., p. 897, who remarks, "Either Navicula lyra is very variable, or more than one species has been included under the name." Heiberg, De Danske Diat., p. 80, who includes this form and the variety elliptica. Cleve, Om Svenska och Norska Diat., p. 226. Donkin, N. H. Brit. Diat., p. 14, Pl. ii., fig. 7. Schmidt, Atlas der Diat., T. ii., fig. 16.

River Slaney, Killurin, Bannon, Co. Wexford. Malahide, Portmarnock, Co. Dublin. Seaweeds, Portrush, Co. Antrim. Caum Lough, near Tralee, Lough Gill, Co. Kerry. Salt marsh, Kilcool, Co. Wicklow. Kilkee, Co Clare. Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay Co. Galway. Stomachs of Ascidians, Belfast Lough.

Var. elliptica, (Wm. Smith). Marine.

Valve elliptical; greatly attenuated at the ends; marginal band of striæ very broad; inner band of striæ narrow; intermediate free space between the inner and outer striate bands narrow; incurved in the middle, converging at the attenuated extremities; striæ obviously moniliform; length, about ·0056, breadth, about ·0024. (Plate 33, fig. 2.)

This form was first described by Wm. Smith, who doubtfully considered it a sporangial variety of Navicula elliptica, B. D., Vol. i., p. 48, Pl. xvii., fig. 152 *a*. Subsequently the same author regarded it as identical with Navicula lyra, Ehr., B. D., Vol. ii., p. 93; but judging by the figure which Kützing has given of the latter, there can be little doubt that the forms are not altogether identical. Still, so similar are they, that it seems desirable to represent them as merely varieties. Schmidt, Atlas der Diat., T. ii. fig. 29.

Stomachs of Ascidians, Belfast Lough. Stomachs of Ascidians, Kilkee, Co. Clare. Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Ballysodare, Co. Sligo. Bannow, Co. Wexford.

Var. grunorii, (O'Meara). Marine.

Valve broadly elliptical; marginal band of striæ very broad; inner band of striæ narrow; intermediate space between the inner and outer bands of striæ narrow, converging, and anastomosing at the ends; striæ very close, radiate, minutely punctate; length ·0028, breadth ·0015. (Plate 33, fig. 3.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 532, T. v., fig. 22. The author just named regards the form as identical with Navicula Lyra, Ehr., as described by Kützing, Bac., p. 96, T. xxviii., fig. 55; but comparison of specimens of both will convince the observer that the forms are not identical; so distinct are their details that the present form might almost be regarded as entitled to a distinctive specific name.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. minor, (Grunow). Marine.

This variety resembles that last described, but differs from it in the following characters; the form is much smaller, the ends are broadly rounded, and the lyrate space between the two bands of striæ is much more convex; length ·0015, breadth .0009. (Plate 33, fig. 4.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 532, Pl. v., fig. 23.

Stomachs of Ascidians, Roundstone Bay; Arran Islands, Co. Galway.

Var. forcipata, (Greville). Marine.

Valve elliptical, oblong; marginal and inner bands of striæ separated by a broad lyrate, blank space; convergent at the ends; striæ, minutely moniliform; length about ·0024, breadth about ·0010.

Greville, Q. J. M. S. 1859, p. 83, Pl. vi., figs. 10, 11. Ralfs, in Pritch., p. 897. Rab. Fl. Eur., Alg., sect. i., p. 178. Donkin, N. H.

Brit. Diat., p. 12, Pl. ii., fig. 4. And likely the same as that figured by Schmidt, Atlas der Diat., T. ii., fig. 36.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Bannow, Co. Wexford. Malahide, Portmarnock, Piles of wooden bridge, Dollymount strand, Dalkey, Co. Dublin. Rostrevor, Dundrum Bay, Co. Down. Lough Gill, Co. Kerry.

Var. abrupta, (Gregory). Marine.

Like the last described variety, but the striæ are costate, and the intermediate lyrate free space does not extend so near the ends.

Gregory, Diat. of Clyde, p. 486, Pl. ix., fig. 14. Rab. Fl. Eur., Alg., sect. i., p. 178. Donkin, N. H. Brit. Diat., p. 13, Pl. ii., fig. 6. Gregory and Donkin figure the species with obscurely moniliform striæ; and therefore I have a doubt of the identity of the present variety with that so described. Supposing the figures referred to be exact in this particular, I could scarcely distinguish between the former and Navicula lyra, var. elliptica.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Var. costata. (O'Meara). Marine.

Valve broadly elliptical; marginal band of striæ broad; inner band of striæ narrow; striæ distinctly costate, close, parallel in the middle, slightly radiate towards the ends, which latter are slightly cuneate; intermediate lyrate space very narrow, convergent at the ends, and reaching to the apices; length ·0024, breadth ·0012.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. seductilis, (Gründler). Marine.

Valve narrow, linear-elliptical; marginal band of striæ relatively wide; inner band of striæ narrow; striæ very fine, linear, parallel in the middle, slightly, radiate towards the ends, lyrate smooth space very narrow; length about ·0020, breadth about ·0006.—Navicula seductilis (Gründl), Schmidt, Atlas der Diat., T. ii., fig. 35. Yokohama. (Plate 33, fig. 5.)

Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. constricta, (O'Meara). Marine.

Valve linear, elliptical, slightly constricted in the middle, ends cuneate, rounded at the extremity; striæ, fine, moniliform, lyrate; free space narrow, converging at the ends; length ·0042, greatest breadth ·0016, breadth in the middle ·0015. (Plate 33, fig. 6.)

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula pygmæa, (Kütz..) Marine or brackish water.

Valve linear, elliptical; marginal band of striæ narrow, with a distinct ridge on the inner margin; inner band of striæ relatively broad, reaching the median line, and having a distinct ridge on the outer margin; striæ fine, linear, nearly parallel; space intermediate between the inner and outer bands of striæ narrow, lyrate; apparently unstriate, but on closer inspection it will be found that the striæ which seem to be interrupted are really pervious; length about ·0015; breadth about ·00066, but often of much larger dimensions. (Plate 33, fig. 7.)

Wm. Smith (B. D., Vol. ii., p. 91), who attributes the species to Kützing. Rabenhorst (Süssw. Diat., p. 39) refers to a form under this name without a figure; the species is not correctly included among those incidental to fresh water. Ralfs, in Pritch., p. 899, who says "the species occurs in brackish or fresh water;" but though often found by me in marine gatherings, it never once occurred to me in fresh water. Donkin, N. H. Brit. Diat. p. 10, Pl. i., fig. 10. Lagerstedt, Sötvat. Diat. frän Spetzbergen och Beeren Eiland, p. 27.—Navicula minutula, Wm. Sm., B. D., Vol i., p. 48, Pl. xxxi., fig. 274.

Bannow, salt ditch near town of Wexford, River Slaney, near Killurin, Tacumshane, Co. Wexford. Malahide, Portmarnock, Piles of wooden bridge, Dollymount Strand, Co. Dublin. Galway Bay, near town of Galway. Portnacrush, Co. Donegal. Lough Gill, Co. Kerry. On seaweeds, Kilkee, Co. Clare.

Var. cuneata, (O'Meara). Marine.

Valve linear, elliptical, with cuneate ends; marginal band of striæ broad; inner band of striæ narrow; striæ coarse, linear, distant, parallel in the middle, slightly radiate towards .the ends, lyrate; free space narrow, and sometimes difficult to detect; length ·0017; breadth ·0010. (Plate 33, fig. 8.)

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

(k) *Trifasciatæ.*

Distinguished by having the intermediate space between the inner margins of the marginal bands of striæ divided into three distinct longitudinal compartments, one about the median line, and one on either side of the same.

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† *Not constricted in the middle.*

Navicula expleta. N. S. Marine.

Valve broadly elliptical; median compartment nearly linear, slightly incurved towards the ends, next compartments narrow, lunate; marginal band of striæ relatively wide; striæ linear, undulate, divided by about five longitudinal sulci; length about ·0018; breadth about ·0012. (Plate 33, fig. 9.)

This form appears to me obviously identical with that described under the name of Navicula notabilis, passing into the variety expleta, by Schmidt, Atlas der Diat., T. viii., figs. 50, 51 and 52. It seems to be perfectly distinct from Navicula notabilis, and deserving of being marked by a distinct specific name.

Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay; Arran Islands, Co. Galway.

Navicula cynthia, (Schmidt). Marine.

Valves broadly elliptical; ends rounded; median compartment narrow, linear, slightly incurved at the ends, and slightly constricted in the middle compartment at either side, narrow, arcuate, unstriate; marginal striate band broad; striæ fine, close, linear, slightly radiate, divided into two nearly equal parts by a longitudinal sulcus; length ·0012, breadth ·0007. (Plate 33, fig. 10.)

Schmidt, Atlas der Diat., T. viii., fig. 41. This figure does not indicate the longitudinal sulcus which in my specimens divides the marginal band of striæ into two compartments; still I am disposed to regard the present form as at best a variety of the form described by Schmidt.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula sansegana, (Grunow). Marine.

Valve linear, elliptical, ends rounded; median compartment narrow, linear throughout; compartments on either side narrow, very slightly arcuate, striate; marginal striate band relatively broad; striæ linear, sub-distant, parallel in the middle, slightly radiate towards the ends; length ·0020, breadth ·0009. (Plate 33, fig. 11.)

Schmidt, Atlas der Diat., T. viii., fig. 27, who attributes the species to Grunow, but I cannot find it noticed in any of the many papers of that author which I have had the opportunity of consulting.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula arraniensis, N. S. Marine.

Valve small, elliptical; median compartment narrow, slightly constricted in the middle, slightly incurved at the ends; compartments at either side narrow, arcuate, striate; marginal band of striæ narrow; striæ strongly costate, distant, nearly linear. Length ·0012, breadth ·0006. (Plate 33, fig. 12.)

Arran Islands, Co. Galway.

Navicula schmidtii, N. S. Marine.

Valve broadly elliptical, ends rounded; middle compartment narrow, linear, strongly marked; very slightly constricted in the middle, very slightly incurved at the ends; compartments at either side arcuate, unstriate; marginal band of striæ relatively broad; striæ coarse, costate, nearly parallel in the middle, but distinctly radiate towards the ends. (Plate 33, fig. 17.)

Navicula eugenia, Krit., form from Java, Schmidt, Atlas der Diat., T. viii. fig. 45. In my form the costæ are stronger and more remote than in the form described by Schmidt; still I have little hesitation in regarding them as the same species.

Arran Islands. Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula eugenia, (Schmidt). Marine.

Valve linear elliptical; ends rounded; median compartment slightly constricted in the middle, slightly incurved at the ends; compartments at either side arcuate, nearly as wide as the marginal band of striæ, striate; striæ fine, linear, nearly parallel throughout; length ·0002, breadth, ·0007. (Plate 33, fig. 13.)

Schmidt, Atlas der Diat., T. viii., fig. 44. From Campeachy Bay.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula scutellum, (O'Meara). Marine.

Valve broadly elliptical, narrowed and rounded at the ends; median compartment broad, linear, slightly incurved at the ends, slightly constricted in the middle; central nodule large, quadrangular, but slightly incurved at the ends; compartments at either side narrow, unstriate, the ends of the striæ of the marginal band sometimes appearing as beads on the outer edge; marginal striate band broad: striæ costate, nearly parallel in the middle, more and more radiate towards the ends; length about ·0025, breadth about ·0015. (Plate 33, fig. 14.)

Pinnularia scutellum, O'Meara, Q. J. M. S., 1869, p. 151, Pl. xii. fig. 5.

Arran Islands, Co. Galway.

Navicula suborbicularis, (Gregory). Marine.

Valve suborbicular, linear; median compartment wide, with margins distinctly marked, slightly inflexed at the ends, considerably constricted in the middle; compartments at either side tolerably broad; bilunate on the inner margin; marginal striate band broad, lunate on inner edge; striæ radiate, finely costate, with obscure moniliform striæ interposed; the costæ only continued across the contiguous compartment; length ·0025, breadth ·0016. (Plate 33, fig. 15.)

Ralfs, in Pritch., p. 898; Donkin, N. H. Brit. Diat., p. 9, Pl. i., fig. 9. Schmidt, Atlas der Diat., T. viii., fig. 5.—Navicula smithii, var. suborbicularis, Gregory, Diat. of Clyde, p. 15, Pl. ix., fig. 17.

Ascidians, Roundstone Bay; Arran Islands, Co. Galway.

Var. forficula, (O'Meara). Marine.

Valve elliptical, median compartment as in the typical species; compartments at either side very much narrower; marginal striate band wide, projecting towards the central nodule; inner margin bilunate; striæ radiate, costate, with obscure moniliform striæ interposed, the costæ only penetrating the contiguous compartment; length ·0023, breadth ·0014. (Plate 33, fig. 16.)

Schmidt, Atlas der Diat., T. viii., fig. 3.—Pinnularia forficula, O'Meara, Q. J. M. S., 1867, p. 117, Pl. v., fig. 9.

Arran Islands, Co. Galway.

Var. parva, (Schmidt). Marine.

Valve linear, elliptical; median compartment narrow, inflexed at the ends, slightly constricted in the middle; compartment at either side very narrow, bilunate; marginal striate band broad, bilunate on the inner margin; striæ fine, linear, nearly parallel throughout; length ·0014, breadth ·0008.

Schmidt, Atlas der Diat., T. viii., figs. 1 and 2.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula coffeiformis, (Schmidt). Marine.

Valve small, broadly elliptical; median compartment narrow, inflexed at the ends, slightly constricted in the middle; compartments on either side narrow; median striate band relatively wide; striæ fine, linear, slightly radiate; length ·0010, breadth ·0005. (Plate 33, fig. 18.)

Schmidt, Atlas der Diat., T. viii., fig. 7.

Arran Islands, Co. Galway.

†† *Valve constricted to the middle.*

Navicula eudoxia, (Schmidt). Marine.

Valve elliptical, slightly constricted, ends broadly rounded; median compartment narrow, inflexed at the ends, slightly constricted in the middle; compartments at either side narrow, striate; striæ linear, nearly parallel and very faint; marginal striate band narrow; striæ linear, slightly convergent in the middle, slightly radiate towards the ends; length ·0016, breadth at the constriction ·0007, greatest breadth ·0008. (Plate 33, fig. 19.)

Schmidt, Atlas der Diat., T. viii., fig. 19.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula donkinia, (O'Meara). Marine.

Valve slightly constricted; ends somewhat cuneate, rounded; median compartment narrow, slightly inflexed at the ends, slightly constricted in the middle; compartments at either side narrow, arcuate, having very faint striæ; marginal striate band narrow; striæ costate, coarse, sub-distant; nearly parallel in the middle, slightly radiate towards the ends; length ·0015, breadth at the constriction ·0006; greatest breadth ·00066. (Plate 33, fig. 20.)

Schmidt, Atlas, T. xii., fig. 63.—Navicula musca, Donkin, N. H. Brit. Diat., p. 50, Pl. vii., fig. 6, exclusive of Synonyms.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula marginata, (O'Meara). Marine.

Valve very slightly constricted; median compartment broad, slightly inflexed at the ends, slightly expanded in the middle; compartments at either side nearly linear; striæ extremely faint; marginal striate band narrow; striæ costate, not reaching the margin, nearly parallel; length ·0036, breadth ·0011. (Plate 33, fig. 21.)

Pinnularia marginata, O'Meara, Q. J. M. S., 1869, p. 15, Pl. xii., fig. 4.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula subcincta, (Schmidt). Marine.

Valve large, slightly constricted, ends somewhat cuneate, rounded; median compartment broad, inflexed at the ends, slightly constricted in the middle; compartments on either side broad, unstriate; marginal striate band divided into two equal portions by a longitudinal sulcus; striæ costate, close, parallel in the middle, slightly radiate towards the ends; length ·0042, breadth at the constriction ·0015; greatest breadth, ·0016. (Plate 33, fig. 22.)

Schmidt, Biolog. Untersuch. der Nordsee. Diat., p. 87., T. xi., fig. 7.

Arran Islands. Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula archeriana, N. S. Marine.

Valve large, slightly constricted; ends somewhat cuneate, rounded; median compartment broad, inflexed at the ends, constricted in the middle; compartments at either side broad, arcuate; marginal striate band narrow; striæ costate, parallel in the middle, radiate towards the ends; length ·0026, breadth ·0012; at constriction, ·0011. (Plate 33, fig. 23.)

O'Meara, Q. J. M. S., 1874, p. 260, Pl. viii., fig. 9.—Navicula donkinii, Schmidt, Atlas, T. xii., fig. 64. This species is at first view extremely like Navicula donkinii; it is, however, considerably larger, the striæ finer and closer, and valve more deeply constricted.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula incurvata, (Gregory). Marine.

Valve slightly constricted; median compartment tolerably wide, slightly inflexed at the ends, very slightly inflexed in the middle; compartments at either side about the same width as the median, slightly arcuate, unstriate; marginal band of striæ narrow; striæ nearly parallel throughout, fine, tolerably close; indistinctly punctate; puncta very close; length ·0028, breadth ·0009; at constriction, ·0008. (Plate 33, fig. 24.)

Gregory, Q. J. M. S., 1856, p. 44, Pl. v., fig. 13. In this figure the marginal band of striæ is represented as very much wider than it appears to be in any of the very numerous specimens I have met with, and also the compartments on either side of the median line are much narrower; in consequence of this, I was induced to consider the form distinct from that of Gregory, and named it Navicula pellucida, Q. J. M. S., 1867, p. 115, Pl. v., fig. 3. Ralfs, in Pritch., p. 893. Donkin, N. H. Brit. Diat., p. 49, Pl. vii., fig. 4. This figure does not describe the incurved ends and middle of the median compartment. Donkin regards the species as = to Navicula interrupta, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 531, T. iii., fig. 20. If so, Grunow's figure is liable to the same remark as that of Gregory. —Navicula splendida, var. incurvata, Rab. Fl. Eur. Alg., sect. i., p. 204. I think the form obviously distinct from Navicula splendida.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway. Stomachs of Ascidians, Co. Clare.

Navicula musca, (Gregory). Marine.

Valve small, deeply and suddenly constricted; ends sharp; median compartment relatively broad, inflexed at ends, slightly constricted in the middle; compartments at either side narrow, arcuate, unstriate; marginal band of striæ narrow, obscurely punctate, extremely short in the middle, radiate towards the ends; length ·0012, breadth ·0006; at the constriction, ·0004. (Plate 33, fig. 25.)

Gregory, Diat. of Clyde, p. 479, Pl. ix., fig. 6. This figure by no means agrees with the description nor the measurements of the text. So that it is not at all to be wondered at that Donkin should have considered it identical with that which he has figured as Navicula musca. Donkin's form referred to was properly regarded by Schmidt as a distinct species, and named Navicula donkinii, the name which I had given to it in my list before the Atlas had come under my notice. The form here described agrees precisely with Gregory's description of Navicula musca, which may readily be distinguished from Navicula donkinii, by its much deeper constriction, and the sharp outline at the ends, in consequence of which it resembles the abdomen of a fly; the striæ, too, in this are punctate, while in the other they are costate.

Piles of wooden bridge on Dollymount Strand, Co. Dublin.

Navicula interrupta, (Kützing). Marine.

Valve deeply constricted; lobes suborbicular; median compartment broad, greatly inflexed at the ends, considerably constricted in the middle; compartments on either side very narrow, bilunate, unstriate; marginal band of striæ very narrow in the middle, where the striæ seem to fail, but tolerably wide in the middle of the lobes; striæ costate, nearly parallel in the middle, radiate towards the ends; length ·0023, breadth, ·0010; at constriction ·0007. (Plate 33, fig. 26.)

Kütz. Bac., p. 100, T. xxix., fig. 93. Ralfs, in Pritch., p. 894. Rab. Fl. Eur. Alg., sect. i., p. 205. Donkin, N. H. Brit. Diat., p. 47, Pl. vii., fig. 2. Schmidt, Atlas, T. xii., fig. 2.—Navicula didyma, Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 154a.

Ballysodare, Co. Sligo. Lough Gill, Co. Kerry. Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, Co. Galway. Seaweeds, coast of Co. Clare.

Navicula apis, (Ehr.) Marine.

Valve deeply constricted, ends narrowed and rounded; median compartment broad, with well-defined boundary lines, slightly inflexed at ends, slightly constricted in the middle; compartments at either side unstriate, narrow, tapering to a point at the ends; marginal band of striæ narrow in the middle, increasing considerably, and then narrowing towards the ends; striæ in the middle apparently costate, convergent towards the ends, radiate, and having the appearance more of fine costæ interrupted by close longitudinal sulci, than of being moniliform; length ·0038, breadth ·0011; breadth at the constriction ·0008. (Plate 33, fig. 27.)

There is great difficulty in identifying the species so named, and with some hesitation have I come to my conclusion on the subject. Kützing's figure of Navicula apis is shorter and stouter than the present, and the striæ are so indistinct as to furnish no help. Donkin's figure in outline is precisely the same as in the form under consideration; the striæ, however, are represented as more decidedly punctate, and the compartments on either side of the median one are distinctly striate. In the present case, there is sometimes an appearance of striæ there, but with precise focusing they disappear, or, if they appear at all, are very faint. Schmidt's figure represents the species as more robust than mine, but the compartments on either side of the median one are just as in mine.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula bombus, (Ehr.) Marine.

Valves much constricted, lobes much inflated; median compartment very wide, the boundary lines strong, and having the edges milled, greatly curved at the ends, slightly constricted in the middle; compartments at either side narrow; scarcely striate, or if striate, the striæ very faint; marginal band of striæ very wide; striæ remote, distinctly moniliform, the beads being distant, parallel in the middle, more and more radiate towards the ends; length ·0036, breadth 0016; breadth at the constriction ·0010. (Plate 33, fig. 28.)

Ralfs, in Pritch., p. 893, who attributes the species to Ehrenberg. Gregory, Diat. of Clyde, p. 484, Pl. ix., fig. 12. Rab. Fl. Eur. Alg., sect. i, p. 204. Donkin, N. H. Brit. Diat., p. 50, Pl. vii., fig. 7a. This figure fairly represents the characters of the species, but in my specimens the constriction is deeper, and the compartments at either side of the median one are much narrower. Cleve, Om Svenska och Norska Diat., p. 226.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway. Ballysodare, Co. Sligo. Malahide, Portmarnock, Co. Dublin. Bannow, Co. Wexford. Stomachs of Ascidians, coast of Co. Clare. Stomachs of Ascidians, Belfast Lough, Co. Antrim.

Navicula entomon, (Ehr.) Marine.

Valves not so deeply constricted as in Navicula bombus; median compartment narrow, inflexed at the ends, slightly constricted in the middle; compartments at either side narrow, unstriate, or striæ very obscure; marginal band of striæ broad; striæ distinctly moniliform, distant, parallel in the middle, radiate towards the ends; length ·0030, breadth ·0012; breadth at the constriction ·0010.

This species strongly resembles Navicula bombus in the character of the moniliform striæ; the constriction is, however, not so deep, nor are the lobes so much expanded; the median compartment also is much narrower in this species than it is in the other.

Kütz. Bac., p. 100, T. xxviii., fig. 74. In this case, the figure is very obscure. Kützing attributes the species to Ehrenberg. Ralfs, in Pritch., p. 893. Donkin, N. H. Brit. Diat., p. 49, Pl. vii., fig. 5. This figure represents the species as much larger, and the compartments on either side of the median one wider than they appear in my specimens. Schmidt, Atlas der Diat., T. xii., fig. 51. In outline, this figure exactly represents the present species; the striation, however, seems different.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula didyma, (Ehr.) Marine.

Valves slightly constricted; median compartment wide, inflexed at the ends, greatly constricted in the middle; compartments on either side very narrow, exhibiting a row of moniliform dots on the inner margin; marginal striate band broad; striæ radiate throughout, closely moniliform; length about ·0030, breadth ·0011; breadth at the constriction ·0010. (Plate 33, fig. 29.)

Kütz. Bac., p. 100, T. iv., fig. 7, T. xxviii., fig. 75. In the former figure, the compartments at either side of the median one are represented as much wider than in my specimens; in the latter figure the striæ are represented as running up to the outer margin of the median compartment, the compartments at either side being thus wholly obliterated. Kützing attributes the species to Ehrenberg. Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 54. Ralfs, in Pritch., p. 893, Pl. xii., fig. 15. Ralfs' figure of the species, Pl. vii., fig. 61, is more like Navicula interrupta than Navicula didyma. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 530. Cleve, Om Svenska och Norska Diat., p. 225. Donkin, N. H. Brit. Diat., p. 51, Pl. vii., fig. 8.

The form described by Rabenhorst as Pinnularia didyma, Süssw. Diat., p. 46, T. vi., fig. 26, is probably the same as the present species, but if so, its occurrence in fresh water must have been casual.

Bannow, River Slaney, at Killurin, Tacumshane, Co. Wexford. Malahide, Portmarnock, Piles of wooden bridge, Dollymount Strand, Co. Dublin. Lough Foyle, Co. Derry. Salt-marsh, near town of Wicklow. Kilkee, Co. Clare. Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bay, seaweeds near Westport, Co. Galway. Stomachs of Ascidians, Belfast Lough, Co. Antrim.

Navicula splendida, (Gregory). Marine.

Valve large, deeply constricted; median compartment wide, greatly inflexed at the ends, greatly constricted in the middle; compartments at either side narrow, having the inner edge milled; marginal band of striæ narrow in the middle, widening in a graceful curve towards the middle of the lobe, then narrowing towards the somewhat lanceolate ends; striæ convergent in the middle, radiate towards the ends, moniliform, the beads being quadrangular; length ·0040, breadth ·0012; breadth at the constriction ·0007. (Plate 33, fig. 30.)

Gregory, Q. J. M. S., 1856, Pl. v., fig. 14. Ralfs, in Pritch., p. 893. Rab. Fl. Eur. Alg., sect. i., p. 204.—Navicula entomon. Donkin, N. H. Brit. Diat., p. 49, Pl. vii., fig. 5. The outline of this form greatly resembles that of Navicula incurvata, which Rabenhorst makes a variety of this species. So different, however, is the character of the striæ, that they cannot properly be considered as nearly related. The present form differs so much, both in outline and striation, from Navicula entomon, that it ought to be considered a very distinct species.

Arran Islands, Co. Galway.

Navicula gregorii, (O'Meara). Marine.

Valves considerably constricted, lobes much expanded, median compartment wide, greatly inflexed at the ends, slightly constricted in the middle; central nodule large, quadrangular, with three short spine-like projections at each side; compartments on either side narrow, attenuated to a point at the ends, roundly expanded in the middle; marginal band of striæ wide; striæ convergent in the middle, radiate towards the ends, moniliform; beads large, quadrangular; length ·0045, breadth ·0028; breadth at the constriction ·0016. (Plate 33, fig. 31.)

Navicula didyma, var. y. Gregory, Q. J. M. S., 1856, p. 45, Pl. v., fig. 16.

Arran Islands, Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula williamsonii, (Wm. Sm.) Marine.

Valve large; margin incurved, rather than constricted; median compartment wide, inflexed at the ends, constricted in the middle; compartments at either side scarcely so wide as the median one, narrowed to a point at the ends, greatly expanded, and anglewise in the middle, striate; marginal band of striæ wide; striæ slightly convergent in the middle, radiate towards the ends, moniliform; beads large, quadrangular; length ·0072, breadth ·0029; breadth at the middle ·0026. (Plate 33, fig. 32.)

Navicula didyma, sporangial var.? Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 154*.—Navicula smithii, Donkin, N. H. Brit. Diat., p. 6, Pl. i., fig. 4. This form on first view would appear to be an incurved variety of Navicula fusca, which it resembles much more than it does Navicula smithii. I believe it is only necessary to see the form, which is extremely rare, in order to be convinced that it is as distinct from Navicula didyma as it is from Navicula fusca. Professor Smith informs us that the species came under his observation in a collection made by Professor Williamson in the Isle of Skye.

Arran Islands; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula incisa, N. S. Marine.

Valve deeply constricted; median compartment narrow; inflexed at ends, slightly contracted in the middle; compartments at either side narrow, striate; striæ faint; marginal band of striæ narrow in the middle, wide towards the middle of the lobes; striæ convergent in the middle, nearly parallel for some distance, and slightly radiate towards the ends; costate, divided into four distinct equal bands, by three deep sulci, which lie conformably with the outer margin; the costæ in each band appear slightly curved; length ·0035, breadth ·0015; breadth at the constriction ·0010. (Plate 33, fig. 33.)

This form somewhat resembles that figured by Schmidt, Atlas der Diat., T. xii., figs. 21 to 24, without a name, and which he thinks stands between Navicula apis and Navicula splendida, but I doubt its identity with either.

Arran Islands, Co. Galway.

Navicula crabro, (Ehr.) Marine.

Valves large, slightly constricted; median compartment narrow, slightly inflexed at ends, constricted in the middle; compartments on either side wider, gently tapering towards the ends; striate, the ends of the striæ appearing as large puncta on the elevated margin of the inner edge; marginal striate band wide; striæ convergent in the middle, radiate towards the ends; costate; length ·0073, breadth ·0021; breadth at constriction ·0015.

Wm. Sm., B. D., Vol. ii., p. 94. Donkin, N. H. Brit. Diat., p. 46, Pl. vii., fig. 1a. Ralfs, in Pritch., p. 894. Rab. Fl. Eur. Alg., sect. i., p. 204.—Diploneis crabro, Ehr., Mic., T. xix., fig. 29. —Navicula pandura, De Brèbisson, Diat. du Littoral de Cherbourg, p. 16, Pl. i., fig. 4.—Pinnularia pandura, var. elongata, Gregory, Diat. of Clyde, p. 489, Pl. ix., fig. 22. Though Ralfs and Rabenhorst seem to regard this form as distinct from Navicula pandura, I am inclined to think with Donkin, that there is no distinction between them. Smith describes the striæ as obscurely moniliform; but all the figures I have seen represent the striæ as distinctly costate, and such I consider is their normal character. Donkin's figure represents the compartments at either side of the median compartment as unstriate, except on the inner edge, where there is a row of large bead-like detached puncta. In all the specimens I have seen, the costæ in this portion, though of a fainter colour, are clearly traceable all through; the large puncta described by Donkin being simply the ends standing out distinctly on an elevated ridge.

Arran Islands; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Var. intermedia, (O'Meara). Marine.

Valve considerably smaller than that of the typical form; the lobes are more expanded; the ends of the costæ on the inner edge of the compartments on either side of the median one are longer, the ridge seeming to be in this case wider, and not so much elevated.

This is, perhaps, identical with Navicula crabro, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 524, T. v., fig. 21, and with Navicula nitida, Gregory, Q. J. M. S., 1856, p. 44, Pl. v., fig. 12.

Broadhaven Bay. Roundstone Bay.

Var. denticulata, (O'Meara). Marine.

Valve very much smaller than the preceding variety, not so much constricted, the ends of the striæ appearing on the inner edge of the compartments on either side of the median one being of the same breadth, or nearly so, as that of the costæ of the marginal band of striæ, which are very narrow. (Plate 33, fig. 34.)

Navicula denticulata, O'Meara, Q. J. M. S., 1867, p. 115, Pl. v., fig. 2. In the description at first given of this form it would appear as if the space between the two bands of costæ were unstriate; but upon more close examination, with better illumination than I then possessed, I have satisfied myself that the costæ pervade the interspace. They are indeed very indistinct, but still traceable.

Arran Islands; Stomachs of Ascidians, Broadhaven Bay; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

Navicula pfitzeriana, N. S. Marine.

Valve small, slightly constricted; median compartment very narrow, lanceolate; compartments at either side become wider in middle than at ends; striate; marginal striate band relatively wide; striæ linear, close, convergent in the middle, thence finer, and nearly parallel; length ·0017, breadth ·0005; breadth at constriction ·0004. (Plate 33, fig. 35.)

This form was a considerable time ago exhibited by me among other interesting species collected by Mr. Mozely, H. M. S. Challenger, on the coast of Patagonia. It is identical with a specimen from Valparaiso, figured as Navicula divergens by Schmidt, Atlas der Diat., T. xii., fig. 53; but as my designation has the priority of publication, it has a right to stand.

Stomachs of Ascidians, coast of Co. Clare.

Navicula vickersii, N. S. Marine.

Valve very large, deeply constricted; median compartment linear, wide; compartments on either side wide, unstriate, bilunate on the outer margin; marginal striate band narrow in the middle, widening towards the broadest part of the heart-shaped lobes, and thence decreasing in width towards the rounded ends; striæ costate, nearly parallel in the middle, convergent towards the ends; a strongly developed submarginal, longitudinal sulcus appears conformable with the outer margin of the valve; length ·0055, breadth ·0020; breadth at the constriction ·0011. (Plate 33, fig. 36.)

This very striking form was exhibited by me some years ago, at a meeting of the Dublin Microscopical Club, at the house of Mr. Henry Vickers, with whose name it is associated.

Arran Islands; Stomachs of Ascidians, Roundstone Bay, Co. Galway.

(1.) *Perstriatæ. Striæ reaching the median line.*

† *Directæ. Striæ parallel.*

Navicula directa, (Wm. Sm.) Marine.

Valve narrow, lanceolate; median line distinct; striæ finely costate; length ·0025, breadth ·0003. (Plate 34, fig. 4.)

Ralfs, in Pritch., p. 906. Cleve, Om Svenska och Norska Diat., p. 224.—Pinnularia directa, Wm. Sm., B. D., Vol. i., p. 56, Pl. xviii., fig. 172. Rab. Fl. Eur. Alg., sect. i., p. 217.

Malahide, Co. Dublin. Stomachs of Ascidians, Co. Clare.

Navicula lanceolata, (Kütz.) Fresh water.

Valve lanceolate; striæ punctate; length ·0016, breadth ·0004.

Kütz. Bac., p. 94, T. xxviii., fig. 38; T. xxx., fig. 48. Neither of these figures indicates the character of the striæ; it is therefore impossible to identify Kützing's species with certainty. Wm. Sm., B. D., Vol. i., p. 46, suppl. Pl. xxxi., fig. 272. Rab. Fl. Eur. Alg., sect. i., p. 171. This author attributes the species to Wm. Smith, who has described it so that it can be easily recognised, and regards it as distinct from that so named by Kützing.

River Bann, near Coleraine, Co. Derry. Kilcool, Co. Wicklow. Adregoole, Co. Galway.

Navicula exilis, (Kütz.) Fresh water.

Valve small, narrow, elliptical; ends produced and slightly capitate; striæ obscure; length ·0013, breadth ·0003. (Plate 34, fig. 2.)

Kütz. Bac., p. 95, T. iv., fig. 6. This figure does not represent the striæ. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 553, T. iv., fig. 30. Rab. Fl. Eur. Alg., sect. i., p. 198.

Lough Mask, near Tourmakeady, Co. Mayo.

† † *Radiosæ. Striæ more or less distinctly radiate.*

Navicula radiosa, (Kütz.) Fresh water.

Valve lanceolate, obtuse; striæ strongly costate; convergent in middle, radiate towards the ends; length about ·0020, breadth about ·0005. (Plate 34, fig. 3.)

Kütz. Bac., p. 91, T. iv., fig. 23. Ralfs, in Pritch., p. 905. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860. Cleve, Om Svenska och Norska Diat., p. 225. Lagerstedt, Sötv. Diat. frän Spitzbergen och Beeren Eiland, p. 25.—Pinnularia radiosa, Wm. Sm. B. D., Vol. i., p. 56, Pl. xviii., fig. 173. Rab. Fl. Eur., Alg., sect. i., p. 214.

Pool, Glengariff, Co. Cork. Lower Lake, Killarney, Co. Kerry. Stream Crossdoney, Co. Cavan. River Dodder, Bohernabreena, Glenasmole, Killakee, Co. Dublin. Lake near Castlewellan, Co. Down.

Navicula gracilis, (Ehr.) Fresh water.

Valve lanceolate, attenuated towards the ends, which are obviously produced; striæ costate, convergent in the middle, radiate towards the ends; length about ·0022, breadth about ·0005. (Plate 34, fig. 4.)

Kütz., Bac., p. 91, T. iii., fig. 48, T. xxx., fig. 57, who regards the species described by him as identical with Navicula gracilis, Ehrenberg, Infus., 1838, p. 176, T. xiii., fig. 2. Smith is doubtful as to the identity of the form described and figured by him with that of Kützing just referred to and comparison of the figures of Kützing with specimens of the form, so accurately delineated by Smith will impress something more than doubt upon the observer's mind. Ralfs, in Pritch., p. 906. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 526, T. iv., fig. 27. The species is broader, more attenuated at the ends, than this figure represents it. Schumann, Diat., der Hohen Tatra, p. 69. Rab. Fl. Eur., Alg., sect. i., p. 174.—Pinnularia gracilis, Wm. Smith, B. D., Vol. i., p. 57, Pl. xviii., fig. 174.

Drumoughty Lough, near Kenmare, Co. Kerry. Stream, Bellarena, Co. Derry. Stream near Crossdoney, Co. Cavan. Stream, Killiney, Stream, Ballybrack, Co. Dublin.

Navicula acuta, (Wm. Smith). Fresh water.

Valve, narrow, lanceolate; ends acute; striæ costate, convergent in the middle, radiate towards the ends; length ·0046, breadth ·0005. (Plate 34, fig. 5.)

Pinnularia acuta, Wm. Sm., B. D., Vol. i., p. 56, Pl. xviii., fig. 171.—Navicula radiosa, var. acuta. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 526. There is a form described and figured by Kützing under the name of Navicula acuta, the details of which are so indistinct that identification would be impossible, but the outline of the valve is such as to make it certain that it is distinct from the present form. Kütz. Bac., p. 93, T. iii., fig. 69.

In a fossil state, it occurs abundantly in the Lough Mourne deposit. In a living state, I have found it in the following localities: River Erne, near Crossdoney, Co. Cavan. Lower Lake, Killarney, Caumlough near Tralee, Co. Kerry. River Dodder, Pond in Botanic Gardens of Trinity College, Co. Dublin. Kilcool, Co. Wicklow.

Navicula acutiuscula, (Gregory). Marine.

Valve narrow, lanceolate, with acute ends. Striæ costate, slightly radiate throughout; length ·0040, breadth ·0005.

Ralfs, in Pritch., p. 906.—Pinnularia acutiuscula, Gregory, Q. J. M. S. 1856, Trans., p. 48, Pl. v., fig. 21. Rab. Fl. Eur. Alg., sect. i., p. 218.

Stomachs of Ascidians, seacoast, Co. Clare.

Navicula peregrina, (Ehr.) Marine or brackish water.

Valves broadly lanceolate, ends obtuse. Striæ costate, sub-distant, radiate; length ·0046, breadth ·0010. (Plate 34, fig. 6.)

Kütz. Bac., p. 97, T. xxviii., fig. 52. The form was considered by Kützing to be identical with Pinnularia peregrina of Ehrenberg. Ralfs, in Pritch., p. 906. Cleve, Om Svenska och Norska Diat., p. 225, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 523.—Pinnularia peregrina, Wm. Sm., B. D., Vol. i., p. 56, Pl. xviii., fig. 170. Rab. Fl. Eur. Alg., sect. i., p. 213.

Salt ditch near the Town of Wexford, River Slaney, near Killurin, Tacumshane, Co. Wexford. Bellarena, mouth of the River Roe, Co. Derry. Rostrevor, Co. Down. Breaches near Newcastle, Co. Wicklow. Kilkee, Co. Clare. Lough Gill, Co. Kerry. Howth, Co. Dublin. Stomachs of Ascidians, Broadhaven Bay, Co. Galway. A small variety of this species occurred from stomachs of Ascidians Belfast Lough, Co. Antrim.

Navicula zostereti, (Grunow). Marine.

Valve, large lanceolate with sharp ends. Striæ strongly costate, sub-distant, radiate; length ·0056, breadth ·0002. (Plate 34, fig. 7.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 528, T. iv., fig. 23. The locality in which this form was found by Grunow was the Adriatic Sea, from a depth of from two to four fathoms. I know of no other locality in which the species has been discovered save that specified below.—Pinnularia zostereti, Rab. Fl. Eur. Alg., sect. i., p. 218.

Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula cleviana, N. S. Marine.

Valve narrow, elliptical. Striæ strongly costate, convergent, rounded, and sub-distant in the middle, radiate, linear, and closer towards the ends. Two very short costæ are interposed in the middle between the next which run to the median line; length ·0034 breadth ·0008. (Plate 34, fig. 8.)

From stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula digito-radiata, (Gregory). Fresh water.

Valve elliptical, with obtuse ends. Striæ costate, convergent, and distant in the middle, radiate towards the ends; length ·0028, breadth ·0008. (Plate 34, fig. 9.)

Ralfs, in Pritch., p. 904.—Pinnularia digito-radiata, Gregory, Q. J. M. S. 1856, p. 9, Pl. i., fig. 32. Rab. Fl. Eur. Alg., sect. i., p. 215.

Bowen's Court, Co. Cork. River Slaney, near Killurin, Co. Wexford, Lower Lake, Killarney. Caumlough, near Tralee, Co. Kerry. River Barrow, near Clonegal, Co. Carlow. Ditch near Kilcool, Co. Wicklow.

Navicula ergadensis, (Gregory). Marine.

Valve linear, elliptical, ends obtuse, rounded. Striæ costate, convergent in the middle, radiate towards the ends; length ·0026, breadth ·0006. (Plate 34, fig. 10.)

Ralfs, in Pritch., p. 907.—Pinnularia ergadensis, Gregory, Q. J. M. S. 1856, Pl. v., fig. 22. Rab. Fl. Eur. Alg., sect. i., p. 215.

Portmarnock, Malahide, Co. Dublin. Lough Gill, Co. Kerry. Salt ditches near the Town of Galway.

Navicula cyprinus, (Ehr.) Marine.

Valve rhombo-lanceolate, ends somewhat cuneate. Striæ costate, convergent in the middle, radiate towards the ends; length ·0025, breadth ·0007. (Plate 34, fig. 11.)

Kütz. Bac., p. 99, T. xxix., fig. 35. The species is here ascribed to Ehrenberg. The figure, it must be observed, is very inadequate to describe the species, the ends being rounded instead of cuneate, and the striæ parallel instead of being as above described.—Pinnularia cyprinus, Wm. Sm., B. D. Vol. i., p. 57, Pl. xviii., fig. 176. Rab. Fl. Eur. Alg., sect. i., p. 215.

Bannow, River Slaney, near Killurin, Co. Wexford. Lough Foyle. Mouth of River Roe, Co. Derry. Seaweeds near Town of Wicklow. Malahide, Portmarnock, Dalkey, Co. Dublin. Kilkee, Co. Clare.

Navicula galvagensis, N. S. Marine.

Valve oblong, elliptical, ends narrowed and rounded. Striæ costare, radiate; length ·0024, breadth ·0005. (Plate 34, fig. 12.)

Salt marsh near town of Galway; Stomachs of Ascidians, Broadhaven Bay, Co. Galway.

Navicula solaris, (Gregory). Marine.

Valve elliptical, with obtuse rounded ends. Striæ fine, linear, convergent in the middle, and very distinct, radiate towards the ends and less distinct. (Plate 34, fig. 13.)

Gregory, Q. J. M. S. 1856, Trans., p. 43, Pl. v., fig. 10. This figure represents the striæ as shortened in the middle so as to leave a blank space round the central nodule. And such is the appearance presented by the specimens that have come under my notice; but when well focused the blank space disappears, and the striæ are found to reach the median line. Ralfs, in Pritch., p. 904. Rab. Fl. Eur. Alg., sect. i., p. 181.

Ballarena, Co. Derry. Adregoole, Co. Galway. Malahide, Co. Dublin.

Navicula viridula, (Kütz. ?) Fresh water.

Valve elliptical, lanceolate, sometimes slightly produced. Striæ fine, linear, convergent in the middle, radiate towards the ends; length ·0016, breadth ·0005. (Plate 34, fig. 14.)

Kütz., Bac., p. 91, T. xxx., fig. 47; T. iv., figs. 10 and 15. The only one of these figures which at all resembles the present form is the last. Ralfs, in Pritch., p. 905. Cleve, Om Svenska och Norska Diat., p. 225. Lagerstedt, Sötv. Diat. frän Spetsbergen och Beeren Eiland, p. 25.—Pinnularia viridula, Wm. Sm., B. D., Vol. i., p. 57, Pl. xviii., fig. 175. The description is accurate, but the figure represents the costæ as greatly coarser than they are in reality. The effect is to make this species appear scarcely to differ from Pinnularia gracilis. Lagerstedt indeed remarks, "I have considered it right to unite under the above name (Navicula viridula) the two species of Smith, Pinnularia viridula, and Pinnularia gracilis," p. 25. The striæ, however, in the former, are extremely fine, whereas in the latter they are very coarse. Rab. Fl. Eur. Alg., sect. i., p. 214. I think it not unlikely that this form is identical with that which Grunow has described as Navicula rhyncocephala, var. brevis. Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 529, T. iv., fig. 31*c*.

Camolin, Co. Wexford. Lough Gill, Co. Kerry. Killakee, Stream near Clontarf, Co. Dublin .Ditch near town of Sligo. Well, Strokestown, Co. Roscommon.

Navicula heufleri, (Grunow). Fresh water.

Valve very small; lanceolate; central nodule large. Striæ fine; linear, radiate; length about ·0009, breadth about ·0003. (Plate 34. fig. 15.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 528, T. iii., fig. 32. Schumann, Diat. der Hohen Tatra., p. 68. Rab. Fl. Eur. Alg., sect. i., p. 214.

Lough Gill, Co. Kerry. Powerscourt, Co. Wicklow.

Navicula fortis, (Gregory). Marine.

Valve small; broadly lanceolate; rounded at ends. Striæ costate, convergent in the middle, radiate towards the ends; on front view, frustule slightly constricted, with the angles slightly rounded; length ·0017, breadth ·0006.

Ralfs, in Pritch., p. 905. Donkin, N. H. Brit. Diat., p. 57, Pl. viii., fig. 8.—Pinnularia fortis, Gregory, Q. J. M. S., Trans., 1856, p. 47, Pl. v., fig. 19. Rab. Fl. Eur. Alg., sect. i., p. 215.

Lough Gill, Co. Kerry. Arran Islands, Co. Galway. Malahide, Co. Dublin.

Navicula northumbrica, (Donkin). Marine.

Valve narrow, lanceolate; ends acute. Striæ linear, convergent in middle, where they are strongly marked; length ·0019, breadth ·0004. Frustule on front view slightly constricted. (Plate 34, fig. 16.)

Donkin, Q. J. M. S., 1861, p. 9, Pl. i., fig. 5; N. H. Brit. Diat., p. 54, Pl. viii., fig. 1. Rab. Fl. Eur. Alg., sect. i., p. 175.

Bannow, Co. Wexford. Salt ditches near the town of Galway.

Navicula arenaria, (Donkin). Marine.

Valve lanceolate, narrow; ends acute, produced and slightly constricted. Striæ costate, convergent; length ·0019, breadth ·0004. Frustule on front view very slightly constricted. (Plate 34, fig. 17.)

Donkin, Q. J. M. S., 1861, p. 10, Pl. i., fig. 9; N. H. Brit. Diat., p. 56, Pl. viii., fig. 5. Rab. Fl. Eur. Alg., sect. i., p. 177.

Portmarnock, Co. Dublin.

Navicula inflexa, (Gregory). Marine.

Valve lanceolate; slightly depressed at the extremities. Striæ costate, convergent; length ·0018, breadth ·0004. (Plate 34 fig. 18.)

Ralfs, in Pritch., p. 905. Donkin, N. H. Brit. Diat., p. 54, Pl. viii., fig. 2.—Pinnularia inflexa, Gregory, Q. J. M. S., 1856, Trans., p. 48, Pl. v., fig. 20. Rab. Fl. Eur. Alg., sect. i., p. 218. The depression of the valve at the ends is marked by a well-defined line which renders the species easy of identification.

Ballysodare, Co. Sligo. Lough Gill, Co. Kerry. Malahide, Co. Dublin.

Navicula hungarica, (Grunow). Fresh water.

Valve small, oblong; elliptical, ends rounded. Striæ subdistant, strongly costate, radiate; central nodule large; length ·0009, breadth ·0045. (Plate 34, fig. 19.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 539, T. iii., fig. 30. Schumann, Diat. der Hohen Tatra, p. 76. Rab. Fl. Eur. Alg., sect. i., p. 190.

Lough Gill, Co. Kerry. Ditch near town of Sligo. Lough Mask, near Tourmakeady, Co. Mayo.

Navicula carassius, (Ehr.) Fresh water.

Valves small, broadly elliptical; ends broadly and shortly produced. Striæ costate; radiate; length ·0007, breadth ·0003. (Plate 34, fig. 20.)

Kütz. Bac., p. 95, T. xxviii., fig. 67. The description and figure represent the valve as unstriate, but the striæ are quite obvious. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., p. 537, T. iii., fig. 31, and T. iv., fig. 11. Ralfs, in Pritch., p. 900. Donkin, N. H. Brit. Diat., p. 20, Pl. iii., fig. 7. It is more than doubtful if the form described by Donkin as Navicula carassius belongs to this species. The figure represents the form as very much longer, the ends finer and more produced, than is the case in Navicula carassius; the striæ too, are described as granular, the striæ in Navicula carassius are linear. Donkin regards the species as identical with Navicula lacustris, Gregory, Q. J. M. S., 1856, p. 6, Pl. i., fig. 23b., but the true Navicula carassius is broadly elliptical, and not linear, as the former is represented to be. Schumann, Diat der Hohen Tatra, p. 68.

Glenchree, Kilcool, Co. Wicklow. Kilcock, Royal Canal, Enfield, Co. Kildare. Dundrum, Co. Dublin. Killeshin, Queen's Co. Caum Lough, near Tralee, Arraglen, Co. Kerry.

Navicula mutica, (Kütz.) Fresh or brackish water.

Valve small, broadly elliptical. Striæ punctate, radiate; length ·0005, breadth ·0003. (Plate 34, fig. 21.)

Kütz. Bac., p. 95, T. iii., fig. 32, who found the form in rain pools mixed with salt water. Grunow, Verhand. der K. K. Zool.

Bot. Gesell., Band x., p. 538; T. v., fig. 16, who found the species in fresh water as well as in brackish. Ralfs, in Pritch., p. 905. Schumann, Diat. der Hohen Tatra, p. 69. Rab. Fl. Eur. Alg., sect. i., p. 185. It is not improbable that this species is identical with the form described by Gregory as Navicula lepida, var. B.? Q. J. M. S., 1856, p. 7, Pl. i., fig. 25, B.

Bannow, Co. Wexford. Lough Gill, Co. Kerry. In these, fresh water forms and marine were mingled. Glenchree, Killakee, Co. Dublin. Lough Mask, near Tourmakeady, Co. Mayo. The three last-named localities were wholly free from marine influences. Hence I consider that though the form has been found in brackish water, it is essentially a fresh water species.

Navicula semen, (Ehr.) Fresh water.

Valve linear, elliptical, broad; ends broadly and shortly produced. Striæ costate; convergent in middle, radiate towards ends; length ·0018, breadth ·0008. (Plate 34, fig. 22.)

Kütz. Bac., p. 99, T. xxviii., fig. 49, who attributes the species to Ehrenberg. Wm. Sm., B. D., Vol. i., p. 50, Pl. xvi., fig. 141. Heiberg, De Danske Diat., p. 82. Ralfs, in Pritch., p. 900. Donkin, N. H. Brit. Diat., p. 21. Pl. iii., fig. 8. Schumann, Diat. der Hohen Tatra, p. 68.

Stream, Bellarena, Co. Derry. Lough Mourne deposit, Co. Antrim.

Navicula humilis, (Donkin). Fresh water.

Valve small, inflated in the middle, with broad capitate ends. Striæ costate, coarse, subdistant, radiate; central nodule large; length ·0010, breadth ·0003. On front view, frustule quadrangular, slightly constricted in the middle; costæ divergent, leaving a considerable space about the central nodule, which latter appears very highly developed.

Donkin, N. H. Brit. Diat., p. 67, Pl. x., fig. 7. Donkin considers this form identical with Navicula inflata, var. Gregory, Q. J. M. S., 1855, Pl. ii., fig. 20 c.

Lough Gill, Co. Kerry. Lough Mask, near Tourmakeady, Co. Mayo.

Navicula inflata, (Kütz.) Fresh water.

Valve small, inflated in the middle; ends narrowed, produced, and scarcely capitate. Striæ closely granular, radiate; length ·0010, breadth ·00035. (Plate 34, fig. 23.)

Kütz. Bac., p. 99, T. iii., fig. 36. Wm. Sm., B. D., Vol. i., p. 50, Pl. xvii., fig. 158. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 538, T. iv., fig. 41. Ralfs, in Pritch., p. 899. Heiberg, De Danske Diat., p. 82. Donkin, N. H. Brit. Diat., p. 21, Pl. iii., fig. 9.

Lough Mask, near Tourmakeady, Co. Mayo. Ditch near town of Wexford. River near Glencar, Co. Kerry. Rock Mills, Co. Cork. Stream Bellarena, Co. Derry. Glenchree, Kilcool, Co. Wicklow. RiverDodder, Killakee, Co. Dublin.

Navicula mesolepta, (Ehr.) Fresh water.

Valve narrow, triundulate; ends narrowed, capitate; striæ costate, radiate. Length ·0025, breadth ·0006.

Kütz. Bac., p. 101, T. xxviii., fig. 33, and T. xxx., fig. 34, who attributes the species to Ehrenberg. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 520. Ralfs, in Pritch., p. 894. Cleve, Om Svenska och Norska Diat., p. 225.—Pinnularia mesolepta, Wm. Sm., B. D., Vol. i., p. 58, Pl. xix., fig. 182.

Lough Mourne deposit. Common specially in mountain districts.

Navicula anglica, (Ralfs). Fresh water.

Valve broadly elliptical; ends produced; striæ costate; convergent in the middle, radiate towards the ends; length ·0015, breadth·00066, (Plate 34, fig. 24.)

Ralfs, in Pritch., p. 900, who considers the form identical with Navicula tumida, Wm. Smith. Donkin, N. H. Brit. Diat., p. 35, Pl. v., fig. 11. The latter author likewise coincides with Ralfs as to the identity of the species with that of Smith referred to. There is, however, a considerable difference between the forms. In Navicula anglica the valve is larger, the ends less capitate, the striæ more distant than in the case of Navicula tumida; and whereas in the latter the striæ are punctate, in the present form they are plainly costate. Schumann, Diat. der Hohen Tatra, p. 68.

Killakee. Trinity College Botanical Gardens, Co. Dublin. Ditch near Sligo. Lough Gill, Co. Kerry. Lough Mask, near Tourmakeady, Co. Mayo. Dundalk, Co. Louth.

Nar. sublinearis, (Donkin). Fresh water.

Valve in all respects like the tpyical species, except that the outline is nearly linear, and the produced ends wider; length ·0012, breadth ·0005.

Donkin, N. H. Brit. Diat., p. 35. Pl. v., fig. 11 b.

Killakee, Co. Dublin.

Navicula cryptocephala, (Kütz.) Fresh water.

Valve small, narrow, elliptical, with produced slightly capitate ends. Striæ fine, linear radiate; length ·0012, breadth ·0003. (Plate 34, fig. 25.)

Kütz. Bac. p. 95, T. iii., fig. 20. Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 155, Ralfs, in Pritch., p. 901; Cleve, Om Svenska och Norska Diat., p. 228. Donkin, N. H. Brit. Diat., p. 37, Pl. v., fig. 14. Schumann, Diat. der Hohen Tatra, p. 68.

Tacumshane, Co. Wexford. Bowen's Court, Co. Cork. Lough Gill, Co. Kerry. Lough Mask, near Tourmakeady, Co. Mayo. Dysart, Co. Waterford.

Navicula angustata, (Wm. Smith). Fresh water.

Valve very narrow, elliptical; ends produced and slightly capitate. Striæ fine, linear, radiate; length ·0016, breadth ·0003. (Plate 34, fig. 26.)

Wm. Sm., B. D., Vol. i., p. 52, Pl. xvii., fig. 156. Ralfs, in Pritch., p. 901. Castracane, Cataloga di Diat. raccolte nella Val. Intrasca, p. 12. Schumann, Diat. der Hohen Tatra, p. 68.—Navicula cryptocephala, var. rhyncocephala, Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 527, T. iv., fig. 28*b*.

Bantry, Co. Cork. Black Castle, Co. Wicklow. Malahide, Co. Dublin. Lough Mask, near Tourmakeady, Co. Mayo.

Navicula lagerstedtii, N. S. Fresh water.

Valve small, rhombic; ends slightly produced. Striæ obviously punctate, radiate, sub-distant; when the centre is not exactly in focus, there is the appearance of a narrow stauroform band, which disappears when properly focused; length ·0010, breadth ·0005. (Plate 34, fig. 27.)

Lough Mask, near Tourmakeady, Co. Mayo. Lough Gill, Co. Kerry. In the latter, marine and fresh water species were mingled, but in the former locality marine influence was impossible; the form is therefore to be regarded as inhabiting fresh water.

Navicula gastrum, (Ehr). Fresh water.

Valve rhombic; ends scarcely produced. Striæ linear, convergent in the middle, radiate towards the ends; length ·0018, breadth ·0009. (Plate 34, fig. 28.)

Kütz. Bac., p. 94, T. xxviii., fig. 56, who regards the species as identical with Pinnularia gastrum, Ehrenberg. Ralfs, in Pritch., p. 900. Donkin, N. H. Brit. Diat., p. 22, Pl. iii., fig. 10. This figure represents the form as much narrower, and the ends more produced than is the case in my specimens.—Pinnularia gastrum, Rab. Süssw. Diat., p. 44, T. vi., fig. 15. This last figure represents the striæ as parallel, which is not accurate. Gregory, Q. J. M. S., 1855, p. 41. Plate iv., fig. 20.

Dundalk, Co. Louth. Lough Gill, Co. Kerry. Lough Mask, near Tourmakeady, Co. Mayo. Lough Mourne deposit.

Navicula binodis, (Ehr). Fresh water.

Valve small, narrow, incurved; ends produced, apiculate. Striæ fine, linear, radiate; length ·0012, breadth ·0004; breadth in the middle ·00035. (Plate 34, fig. 29.)

Kützing (Bac., p. 100, T. iii., fig. 35,) considers the form identical with that so named by Ehrenberg. Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 159. Rab. Süssw. Diat., p. 41, T. v., fig. 5, and Fl. Eur. Alg., sect. i., p. 203. Ralfs, in Pritch., p. 893. Castracane, Catalogo di Diat. raccolte nella Val. Intrasca, p. 12. Heiberg, De Danske Diat., p. 83. Cleve, Om Svenska och Norska Diat., p. 227. Donkin, N. H. Brit. Diat., p. 38, Pl. vi., fig. 3. Schumann, Diat. der Hohen Tatra, p. 77.

Powerscourt, Co. Wicklow. Lough Gill, Co. Kerry. Donkin considers this species as one which occurs frequently in England; it is, however, one of very rare occurrence in Ireland.

Navicula dicephala, (Ehr.) Fresh water.

Valve small, narrow, linear, narrowing towards the produced slightly capitate ends. Striæ obvious, convergent in the middle, radiate towards the ends; length ·0014, breadth ·00055. (Plate 34, fig. 30.)

Kütz. Bac., p. 96, T. xxviii., figs. 60 and 62; these figures incorrectly describe the striæ as parallel. Kützing attributes the species to Ehrenberg. Wm. Sm., B. D., Vol. i., p. 53, Pl. xvii., fig. 157. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x,, p. 538, T. iv., fig. 45. Ralfs, in Pritch., p. 902.

Lough Gill, Co. Kerry. Lough Neagh, near Lurgan, Co. Armagh. Camolin, Co. Wexford. Friarstown, Lucan, Killakee, River Dodder, Co. Dublin. Cushendun, Co. Antrim. Powerscourt, Co. Wicklow. Lough Mourne deposit.

Navicula rhyncocephala, (Kütz.) Fresh water.

Valve narrow, elliptical; ends considerably produced, not capitate. Striæ distinct, closely moniliform, radiate; length ·0025, breadth ·0006. (Plate 34, fig. 31.)

Kütz. Bac., p. 152, T. xxx., fig. 35. Wm. Sm., B. D., Vol. i., p. 47, Pl. xvi., fig. 132. Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 530, T. iv., fig. 32. Heiberg, De Danske Diat., p. 82. Ralfs, in Pritch., p. 900, Pl. vii., fig. 68. Cleve, Om Svenska och Norska Diat., p. 227. Schumann, Diat. der Hohen Tatra, p. 68. Rab. Fl. Eur. Alg., sect. i., p. 196. Donkin, N. H. Brit. Diat., p. 38, Pl. vi., fig. 4.

River Dodder, ditch, Dundrum, Co. Dublin. Caumlough, near Tralee, Co. Kerry. Ulster Canal, near Poyntzpass, Co. Armagh. Kilcool, Co. Wicklow.

Navicula globifera, N. S. Fresh water.

Valve narrow, margin slightly constricted; ends constricted and broadly capitate. Striæ extremely fine, close, convergent; length ·0018, breadth ·0003. (Plate 34, fig. 32.)

This form is very similar to that described by Gregory as Pinnularia globiceps, Q. J. M. S., 1856, p. 10, Pl. i., fig. 34; but differs in the following respects: in Gregory's form the valve is obviously expanded in the middle; in this it is linear, with the appearance of a slight constriction in the middle; the striæ in this are much finer, and reach the median line, instead of leaving a central stauroform free band, as is the case with Pinnularia globiceps.

Camolin, Co. Wexford.

Navicula rostellifera, (Gregory). Marine or brackish water.

Valve minute, narrow, linear; narrowed towards the ends, which are apiculate. Striæ costate, convergent in the middle; frustule on front view constricted in the middle; length of valve .0013, breadth ·0003. (Plate 34, fig. 33.)

Pinnularia apiculata, Gregory, Q. J. M. S., 1856, p. 41, Pl. iv., fig. 21. This form appears to be the same which Donkin describes as Navicula apiculata, De Brèbisson, and Pinnularia rostellata, Gregory, Diat., of Clyde, p. 488, Pl. ix., fig. 20. See Donkin, N. H. Brit. Diat., p. 56, Pl. viii., fig. 6. Gregory himself evidently regarded the forms as distinct; and comparison of the two compels me to coincide with that eminent observer. Navicula apiculata, De Brèbisson, and Pinnularia rostellata, Gregory, are obviously identical, and quite different from the present, which is much smaller and narrower in proportion; the striæ being very strong, and reaching the median line, while in this other they leave a considerable blank space about the central nodule; the rostrate ends too in the latter are much produced, while in this species they are very short. Gregory's specific term apiculata having been appropriated by De Brèbisson, ought to drop, and the form so distinctly described by Gregory bear another designation, to avoid confusion.

Lough Gill, Co. Kerry. Portmarnock, Co. Dublin.

Navicula cancellata, (Donkin). Marine.

Valve large, narrow, linear, with cuneate ends. Striæ strongly costate; convergent in the middle, nearly parallel towards the ends; length ·0036, breadth ·0006. Frustule on front view slightly constricted, the costæ appearing in a broad band. (Plate 34, fig. 34.)

Donkin, N. H. Brit. Diat., p. 55, Pl. viii. fig. 4. Navicula truncata, Donkin, Q. J. M. S., 1861, p. 9, Pl. i., fig. 4, and changed for the present designation, the former name having been anticipated by Kützing.—Pinnularia truncata, Rab. Fl. Eur. Alg., sect. i., p. 217.

Arran Islands; Stomachs of Ascidians, Roundstone Bay; Stomachs of Ascidians, Broadhaven Bray, Co. Galway. Malahide, Portmarnock, Co. Dublin.

Navicula minor, (Gregory). Marine or brackish water.

Valve small; linear with cuneate ends, striæ linear, nearly parallel in the middle; slightly radiate towards the ends; length ·0012, breadth ·0004. (Plate 34, fig. 35.)

Gregory, Diat. of Clyde, p. 477, Pl. ix., fig. 1. Gregory mentions that in this species the striæ do not reach the median line. In this particular, the present form does not answer Gregory's description, inasmuch as the striæ plainly reach the median line, but in all other respects there is such agreement as to make me think the forms are identical. Ralfs agrees with Gregory in all particulars, p. 909. Donkin describes a form under this name which he regards as identical with that described by Gregory. See N. H. Brit. Diat., p. 57, Pl. viii., fig. 7. The forms, however, are obviously different, that of Donkin being elliptical, lanceolate, while Gregory's is linear, with cuneated apices.

Piles of wooden bridge, Dollymount Strand, Co. Dublin. Lough Gill, Co. Kerry.

(m) *Diaphanæ. Striæ not observable.*

Navicula perpusilla, (Grunow). Fresh water.

Valve minute. linear, oblong, with rounded ends, and slightly expanded in the middle; length ·0005, breadth ·0002. (Plate 34, fig. 36.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 552, T. iv., fig. 7*a*.

Lough Mask, near Tourmakeady, Co. Mayo.

Navicula seminulum, (Grunow). Fresh water.

Valve very minute, oblong, elliptical, with rounded ends; length ·0006, breadth ·00025. (Plate 34, fig 37.)

Grunow, Verhand. der K. K. Zool. Bot. Gesell., Band x., 1860, p. 552, T. iv., fig. 2.

Lough Mask, near Tourmakeady, Co. Mayo.

EXPLANATION OF CONTRACTIONS AND LIST OF REFERENCES.

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INDEX TO REPORT, PART I., ON THE IRISH DIATOMACEÆ.

The Families, Sub-families, and Genera are printed in Small Capitals, the Species in ordinary type. Synonyms are marked with an asterisk.

XXXVIII.—Notes on some Anomalies in the course of Nerves in Man. By Alexander Macalister, M.B., Professor of Zoology and Comparative Anatomy, Dublin University, M.R.I.A.

[Read November 8, 1875.]

The following are some varieties which I have noticed in the course of nerves, in the Dissecting Room of the University of Dublin.

1st. In a thin middle-aged female subject, a nerve, about as large as the buccal, arose from the temporo-auricular, after the union of the two roots of that trunk, it then passed over the internal maxillary artery (which was normal) and was joined by a small twig which arose from the inferior dental nerve, directly below the foramen ovale (thus making a loop around the artery). The trunk so formed descended anterior to the usual inferior dental trunk, and pierced the mandible at a point on the inner side of the bone opposite the mental foramen, entered the inferior dental canal and supplied the incisor teeth. The normal inferior dental nerve was smaller than usual, and lay posterior to this anomalous trunk, from which it was separated by the internal maxillary artery; the mental nerve was large, and was the terminal branch of the inferior dental, all the filaments of that nerve leaving the inferior dental canal at this point.

Cruveilhier and Sappey describe a fine anastomosis between the auriculo-temporal and the inferior dental, but I am not aware of this variety of that union having been previously observed.

2nd. In a female subject the hypoglossal nerve, about half-an-inch internal to its thyro-hyoid branch, gave off a transverse branch of communication to its fellow of the opposite side; this medial branch arose below the twig for the genio-hyoid, and passed superficial to that muscle and under the mylo-hyoid; in size the communicating trunk was nearly equal to the continued trunk of that nerve.

Communications between the hypoglossals of the two sides are on record thus: Szabadföldy (Virchow's Archiv. Band 38, s. 177) saw twigs of the hypoglossus of one side passing through the septum of the tongue to the opposite side; Bach (Annotationes Anatomicæ de nervis hypoglosso et laryngeis: Turici, 1834, p. 10) noticed a sling-like union of the two hypoglossi in the tip of the tongue, and my case seems to be a variety, on a lower level and large scale, of that method of union.

3rd. The last specimen to which I will at present allude is one of not very uncommon occurrence. In a female subject the phrenic nerve arose as usual by a large root from the fourth cervical nerve (its main root as shown by Luschka and others), but its usual accessory branch from the fifth came off rather larger than usual, and lower down than usual from its parent trunk; it then ran down parallel to the main root but 0·5″ behind it, under the subclavian vein, and the transversalis humeri and colli arteries, passed outside the internal mammary, then across it, and joined the other portion of the phrenic at the level of the upper edge of the first rib. Varieties in the position of these two roots and in their place of union are not uncommon, but I have never seen so low a union before.

XXXIX.—ON THE THEORY OF THE CUP ANEMOMETER, AND THE DETERMINATION OF ITS CONSTANTS. By the Rev. T. R. ROBINSON, D.D., M.R.I.A., F.R.S., &c.

[Read December 13, 1875.]

I HAVE described this instrument in a paper which the Academy did me the honour to publish in their "Transactions,"* and I endeavoured to approximate to its theory by applying to it Borda's Theorem for Undershot Wheels, and adding terms for the resistance due to the motion of the cups in quiescent air, and to friction. In respect of the coefficients, I determined in actual wind the ratio of the pressures on the concave and convex surfaces of the cups at perpendicular incidence, and measured the difference of these pressures, by a spring-balance connected with the axle of my Anemometer (12-inch cups with arms of 24) for velocities of wind given by a smaller instrument, of known relation to the large one. The resistance due to the rotation was measured by the forces required to make the cups revolve with given velocities, and the friction similarly measured. These data enabled me to compute the ratio of the wind's velocity to that of the Anemometer, supposing friction null, which I found = 2·999, and to make corrections for that element of resistance. There were in this three doubtful assumptions; that the *mean* ratio of the antagonist pressures was the same as that at a perpendicular incidence; that Borda's formula is strictly applicable to curved surfaces moving in a free current; and that the resistance in quiescent air is the only one to be considered in that term of the equation which includes v^2. I therefore had very little confidence in this theory. However, I tested it by experiment. A small Anemometer was fixed to a whirling machine which carried it through the air with velocities varying from 11·69 miles an hour to 3·93. And 33 such observations gave for the ratio 3·004. In water it gave 3·020, the results with 2, 3, and 4 cups being almost identical. I tried to ascertain the agreement of this instrument with the large one, by comparing their simultaneous readings, but the irregularity of the wind, even at a few feet distance, made the trial ineffectual. However, the agreement of the two ratios given above seemed satisfactory, and I pursued the investigation no farther, till my attention was recently recalled to it by a memoir† by M. Dohrandt, of the Petersburgh Meteorological Observatory, which appeared in the "Repertorium für Meteorologie," containing an elaborate series of experiments made chiefly to determine the relation between the rotation-velocity of the Cup Anemometer and that of the wind.

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* Transactions, Vol. xxii., Part I., Science, p. 155.
† Repertorium für Meteorologie, Band iv., 1874.

They were made by means of the whirling machine invented by Robins 130 years ago, and subsequently used by other English physicists for experiments on the air's resistance. This apparatus was established in the Hall of the Central Physical Observatory at St. Petersburgh on a grand scale. Its horizontal arms were 11·26 feet long, braced to prevent flexure, and 20·3 feet above the floor. The Anemometers were attached to one of the arms at 10·92 feet from the centre of rotation, and, except in one instance, with their planes of rotation parallel to that of the arms. The number of turns of the latter was recorded by an electric register, and the seconds of each experiment noted with a chronometer. These gave the velocity with which the axis of the Anemometer passed through the air. It was moved, in a way not corresponding to the general excellence of its details, by two men impelling opposite bars projecting from the axle; and therefore the velocities communicated to it were not very uniform. The greatest speed obtained was 40 kil. = 25 miles per hour.

The velocity with which the centre of its cups revolved was given by the number of its revolutions and its radius. M. Dohrandt was well aware of the circumstances which make a difference between the motion of an Anemometer carried through quiescent air, and of one acted on in a fixed station by a current of wind; and he showed great sagacity and experimental skill in trying to eliminate the influence of the two most important of them.

First, it is obvious that a cup which is within the track of its axis meets the air with less velocity than one outside, and therefore receives a less impulse than when outside; from which it follows that when the machine revolves in the same direction with the Anemometer, the latter revolves more slowly than in the reverse case. He, therefore, in every case took the mean result of the two directions.

Secondly, the rotation of the apparatus drags with it a quantity of air, producing a circular current which is sensible even at the floor 20 feet below; therefore the Anemometer meets the air with a less velocity than if that were quiescent. He measured this draught by a "Woltman's Fly," a light windmill, established with its axis nearly in the plane of the Anemometer's rotation, and parallel to the tangent of its track, and from 12 inches to 20 inches from that track. He estimated its velocity to be about 0·05 of that of the machine, and, allowing for it, concluded that V, the velocity with which an Anemometer is moved through still air, is connected with v the velocity of the centre of the cups by the equation $V = a + bv$ (in kilom.)

He determined these constants for five Anemometers by the whirling machine; and four others by comparison with them. I give their values for the first set, adding for each the length of its arms and diameter of its cups in inches.

NAME OF MAKER.	*a*. Kil.	*b*	Length of radius.	Diameter.
Browning, ...	3·66	2·2271	11·99	5·84
Casella, 317 . . .	2·56	2·7548	6·75	3·015
Casella, 318 . . .	1·90	2·8472	6·76	3·015
Nowikoff, ...	1·81	2·8979	8·61	3·77
No. 4, ...	2·49	2·5293	4·85	4·11

He gives also the result of a trial to determine the constants for Browning by carrying it on the tender of a locomotive to and from Zarsko-Selo, a distance of 19 versts = 20·27 k. He gives the mean V going 32·14 and returning 26·90; and v = 13·76 and 9·17. This reference to hourly velocities rather masks the result, and it is simpler to say that while the engine traversed 20·27, the Anemometer showed 8·675 going and 6·837 returning. The difference is referred to a light wind which blew. He endeavoured to estimate the effects of this by means of an Anemometer Breguet fixed on the tower of the Observatory; but as this was 77 feet above the ground, and from 4 to 25 k. from the rail, he attaches little importance to its data, except inferring that the direction of the wind made a mean angle of 22° with that of the rail; and comparing the V's going and coming, he deduces for the mean velocity of the wind along the rail (*by his formula*, first assuming $a = 2$ and then 3) 2·8; (Breguet would give 5·2). From these he finds for Browning $a = 3·11$; $b = 2·3091$.

Lastly, he placed the two Casellas and Browning on the Observatory tower, where two others were permanently established. But, as the platform was only 10 feet 5 inches square, they must have been too close to act freely. However, he got by his equations very nearly accordant results for the three.* The remainder of the paper is occu-

* Similar but more extensive experiments were made by the Rev. Fenwick Stow ("Meteorological Journal," vol. i.), of which I learned the existence from M. Dohrandt's paper. Six Anemometers of different types from the Kew one, $r = 24$ inches, $d = 9$ inches, to Casella $r = 6.7$, $d = 3.01$, were established on open ground, and their indications were taken during a considerable period, and with values of V, as given by the Kew, ranging from 3^m to 34^m. He finds that instruments with short arms do not agree even approximately with the Kew one, except at low velocities; that those which have the smaller cups relative to the arms, maintain at all velocities a tolerably even percentage of Kew, and that, in all cases (supposing the V given by Kew to be that of the wind), they move more rapidly in proportion to the wind *as V is smaller*. This is in complete opposition to Dohrandt's results, and (as will be seen) to theory. Comparing Casella and Mr.

pied with determining equations for Woltman's Fly, and Wilde's Wind Tablet. Too much praise cannot be given to the ability and care with which these experiments were carried out, and it is not from any failure in these respects that they cannot be depended on to give reliable values of Anemometer constants, or correct the theory of these instruments; but they are all liable to several causes of uncertainty. Even had the apparatus been established in free air, it is probable that the Anemometer's indications would be different from those given by the same instrument if stationary, and acted on by a current of wind. Experiments show that a plane surface moved through water in a direction perpendicular to itself is less pressed than when a stream of water impinges on it with the same velocity. I know Colonel Duchemin's researches only by M. Dohrandt's reference to them, and his results seem excessive; but De Buat's experiments give that the ratio is as 1·186 : 1; Vince makes it 1·2 : 1. The pressure is also differently distributed over the surface in the two cases. It is possible that if the plane were moved down the stream with a less velocity than it has, the difference might be still greater. I am not acquainted with any experiments of this kind made on curved surfaces. Similar differences may be expected to exist between the motion of the body and that of the fluid in elastic media, though we cannot say what would be their amount, supposing them to exist, though probably

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Stow's No. 5, $r = 9$, $d = 4$ inches, with Nowikoff for V nearly equal, and taking $v = \frac{1}{3}$ of his number, as all the instruments register $3v$, I find—

Casella.	Stow.	Casella.	Dohr.	No. 5.	Stow.	Nowikoff.		Casella.	Robinson.
V'	$\frac{V'}{v}$	V'	$\frac{V'}{v}$	V'	$\frac{V'}{v}$	V'	$\frac{V'}{v}$	V'	$\frac{V'}{v}$
34·8	3·936	34·19	3·163	36·0	3·696	33·31	3·225	21·96	3·263
26·2	3·855	25·94	3·275	24·7	3·681	27·29	3·347	16·00	3·564
22·7	3·895	21·16	3·380	21·8	3·644	22·37	3·361	11·40	3·654
20·2	3·816	20·27	3·573	16·3	3·645	15·98	3·463	10·58	3·861
16·2	3·754	15·31	3·599	7·9	3·619	7·74	3·957	9·79	4·140
11·0	3·765	11·12	3·635	..	..	..	..	7·10	4·170
7·4	3·768								

They are also inconsistent with my own observations, made many years ago, to compare a Casella with my own Anemometer; the results of which I give. I regret that I was not acquainted with Mr. Stow's experiments during their progress, as I would have requested him to measure for each of his instruments my constants $\frac{a'}{30} + b$, and f. A knowledge of these might have modified his numbers considerably. He seems to have not duly appreciated the extent to which very slight modifications of the figure of the ground will influence the velocity of the wind, and the considerable variations of it which occur even at small lateral distances. From my own observations of these facts I cannot place any reliance on this mode of determining Anemometer constants.

they would be less.* But, in the investigations which we are considering, the air was far from free. The part of the Hall occupied by the apparatus was 27·4 feet by 26·9 feet; 26·3 feet high in the centre, 22·6 feet at the walls. The rotating arms were 20·3 feet from the ground; but the cross of the Anemometer was only 17·64 inches from the roof (this was necessary from the nature of the frame supporting the vertical axis, which had been constructed for another purpose), and the centres of the cups were from 34 inches to 30 inches distant from the main line of the walls. Part of the Hall communicating with this nearly cubical space was only 11·7 feet high, and on the east wall was a small gallery 15·4 feet above the ground, in which an observer was stationed. It is evident from these details that the air put in motion by the rapid rotation of the arms (11·25 feet long, and 2·4 inches diameter, with braces 8·68 feet long, and 0·6 inches diameter), and by the fixed parts of the Anemometer must have been thrown into irregular eddies, interfering with its action on the curved surfaces of the cups, and that they must have been differently impelled when nearest to the walls, and when opposite to the angles of the room. The current measured by the Woltman cannot be regarded as representing that in the Anemometer track, for, besides being outside that, it must be modified by the gallery and observer's body. He tried to examine it by small balloons filled with coal gas, and loaded so as to be in equilibrio, "but they travelled irregularly, sometimes within, sometimes without the Anemometer's track, sometimes above, sometimes below it."

He found, also, that the revolutions of the Anemometer tried were sensibly diminished, when another one, or even the small Woltman, was put on the other arm 22 feet distant. (I think some useful information as to the motion of the air might have been obtained by placing over the Anemometer a tube as long as its diameter, perforated with several holes, and discharging through these jets of smoke, as was done by Dr. Ball in his experiments on vortex rings). M. Dohrandt has here overlooked three disturbing elements. A part of the resistance to an Anemometer is work done in throwing out from *its* centre a quantity of air by centrifugal force; this must be interfered with by the walls, &c. Another is, that the rotation of the whirling machine itself must, by the same centrifugal force, produce an *outward* current. He refers to this as increasing the density of the air near the walls, but it must escape above and below, and the stream so produced must help to turn the cups. What its amount is cannot, under the circumstances, be determined *a priori*, but it probably more than counteracts the circular current.

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* It is, however, to be remarked, that the small Anemometer mentioned in the beginning of this paper gave almost identical results when carried through air, and when immersed in running water.

Thirdly, the centrifugal force due to the circular track of the Anemometer's axle must make it press against its upper bearing, and thus increase the friction, unless, as in my original instrument, there are mechanical antifriction appliances at this part; but this does not seem to have been the case in those used by M. Dohrandt. With his machine, when $V = 40\ K$, this lateral pressure will be 3·78 times the weight of the moving parts, and the additional friction at the bearing about 0·1 of this.*

It is not quite correct to assume that the mean of the results obtained by rotating the machine in opposite directions is identical with what would have been given by a rectilinear motion; for it cannot be doubted that the equation which gives the relation between V and v, must contain V^2, v^2, and Vv; and it is obvious that half the sums of these will differ from those of the mean, V and v, though not considerably. M. Dohrandt tried to avoid the necessity of this double rotation by (as I had done) making the plane of the Anemometer's rotation perpendicular to that of the arms. In this case the direction of the rotation should make no difference, and the centrifugal current being perpendicular to the Anemometer plane should, but for the eddies, have no effect.† But this is far from being the case. Allowing 0·05 V, for the circular current, the ratio $\frac{V}{v}$ is in the two cases

	$V - M = 32{\cdot}01$ K.	$\frac{V}{v} = 3{\cdot}050$;	$V - M = 32{\cdot}37$ K.	$\frac{V}{v}$ 2·770
No. 4.	24·57	2·558	22·31	2·809
	19·53	3·179	21·84	2·805
	18·74	3·362	15·13	2·974

He remarks that nothing can be made of this, and the reason is obvious, for the axis of the Anemometer is only 2·8 feet from the roof and its cups 2·3 feet. In a freer space, he remarks, this mode would be preferable to the one he employed. With respect to *it*, I think the preceding remarks will suffice to show that it is very doubtful whether his V represents the wind which it is supposed to represent, and that instead of deducting any allowance for the circular current, it might be nearer the truth to add one for the centrifugal forces and the eddies; and certainly the resistance is different from that which would occur in the ordinary use of an Anemometer.

The railway experiment is not more conclusive. No reliance can

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* In one of Casella's construction, of the same dimensions as C 318, the moveable parts weigh 3500 grs. Hence, for $V = 25$ miles, the additional friction would be 19·6 grs. Six times the normal one.

† An Anemometer, with 3-inch cups, fixed to the axle of the vane of my Anemometer, so that its axis was always in the direction of the wind, made 48 revolutions in 6^m. In M. Dohrandt's experiment the eddies were probably much stronger than in the above case.

be placed on his estimation of the wind's effect; and any attempt to combine the results for each verst going and returning seems hopeless. The space, for instance, traversed by the cups, in passing No. 2, are 546·11 me. and 319·25 me.; the Vs are 21·22 k, and 24·38 k; the $\frac{V}{v}$ 1·953 and 3·342; for No. 10, they are 403·3, 386·5; 36·58, 35·98, and 2·645, 2·741.

M. Dohrandt only considers that part of the wind which acts in the mean direction of the rail, but its rectangular component cannot be omitted, for it can turn the Anemometer both going and coming. And there is uncertainty about the real velocity with which the air, in such trials, passes the instrument; a body moving through a fluid carries before and behind it a mass of quiescent fluid, but at the side of a ship it is well known that the water moves astern, in consequence of its displacement in front.

The same is probably the case on the tender of a train, especially between embankments, in which case the V will be greater than what is given in the Table.

His determinations of the ratio differ, as might be expected from the preceding remarks, considerably from mine, always in defect, but unequally in the different instruments. It must, however, be observed, that we mean different things by the term ratio. My $m = \frac{V}{v+u} u$ being a variable, depending on the friction and v;* his is $\frac{V-a}{b}$, a being a constant.† I must also remark that his equation $V = a + bv$ is strong evidence that the circumstances under which his experiments were made are abnormal. In this instrument, when a permanent state of rotation is established, the mean impelling force must be equal to the mean resistance. Now, with all the defects of this branch of Hydrodynamics, it is certain that the equation expressing this equality *must* contain $V^2 v^2$ and Vv; and one in which they do not appear cannot give the V which corresponds to a v produced by the action of the real wind.

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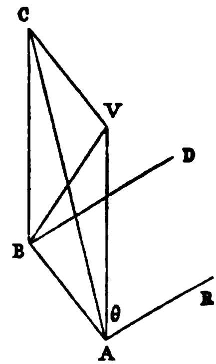
* I wish to correct a mistake in my paper on the Anemometer (l. c.) I stated that m is independent of the size of the instrument, forgetting that b', the co-efficient of that part of the resistance which is caused by centrifugal force, is in part inversely as the arm of the Anemometer. Therefore m must be larger in small instruments than in large ones. On the other hand, the divisor of f is less.

† This constant differs considerably, and more than can be explained by mere friction in his instruments. The two Casellas, which are quite similar, are special examples of this. In those cases where he extends the interpolation to v^2; the a differs from that of the simple equation so much that we can scarcely suppose either to be a true friction co-efficient. It is to be regretted that it did not occur to him to determine the friction of each Anemometer, and the V at which they began to move; a knowledge of these would have made his results more useful.

Notwithstanding these defects in M. Dohrandt's experiments, I think they show the necessity of further investigation; and as I am convinced of the advantages which this instrument possesses as a recorder of the wind's velocity, I think it may be useful to point out the processes by which, as it seems to me, a closer approximation to its theory may be obtained, and the co-efficients of the resulting equation deduced with sufficient certainty. If in doing this I seem to go too minutely into details, I must plead in excuse the great complexity of the inquiry, and my desire to omit nothing of importance.

Considering a single cup of an Anemometer exposed to a current of air of velocity V, making an angle θ with its arm, and incident on its concave surface; its pressure on that surface $= SV^2 \times a$; a being a co-efficient depending on θ, and on the figure of the cup, and S the area of its mouth: the power of this pressure to make the cup revolve is $SaV^2 \times \sin\theta$. But suppose the cup in motion with the velocity v, and convex foremost, this motion lessens the effect of V, and instead of V, we must use the resultant of it and v. This resultant also makes with the arm an angle ϕ, different from θ; let AR be the arm, AV a line proportional to V. $AB \perp$ to AR, as v; the diagonal BV of the parallelogram under them $= R$ the resultant when V and v are in the same direction; $CA = R'$ that when they are in opposite ones. Drawing $BD \parallel$ to AR, $VBD = \phi$. It is obvious that $R^2 = V^2 + v^2 \mp 2Vv \sin\theta$, and



$$\sin\phi = \frac{V\sin\theta \mp v}{R \text{ or } R'}, \quad \cos\phi = \frac{V\cos\theta}{R \text{ or } R'},$$

the lower signs belonging to the case R'. Hence for $SaV^2 \sin\theta$ we must use $SaR^2 \sin\phi = Sa\,(V^2 + v^2 \mp 2Vv\sin\theta) \times \sin\phi$. ϕ is best found by the equation—

$$\tan\phi = \tan\theta \mp \frac{\text{secant}\,\theta}{m}, \quad m \text{ being} = \frac{V}{v}.$$

It will be shown (V.) that m, though changing with v, varies little; and taking its mean value, no important error will arise from assuming it constant.

This is the positive or impelling pressure. (1.)

When $\sin\theta = \frac{1}{m}$, it should vanish; but in fact I found that one cup exposed to the wind has a positive pressure far beyond this point, not resting till 210°. I could not determine the opposite point of rest, because the least eddy of the wind set the cup in rotation. I do not know whether this curious fact arises from the wind eddying into the concave, or from minus pressure behind the cup;* but it is the more remarkable, because in this case more than half a hemisphere is exposed to negative action. This seems to imply that the original expression for the rotating power $SV^2 \times a \sin\theta$, should be of the form $a \sin\theta + b \cos\theta$. As in this case a and b cannot be separated by any experimental process, it will be best to make a include the functions of θ, which express the rotation, so that the power to turn the cup shall be SaR^2_ϕ; and this in general.

Secondly. Putting the opposite cup in its place, while the concave of the first moves from the wind the convex moves against it, and meets a resistance = $Sa'R'^2$ (2.) The co-efficients a and a', are different functions of θ. When it is 90, I determined their ratio to be 4·011: on either side of this the ratio is greater, though the absolute values are less. Both positive and negative pressures are increased a little by the so-called friction of the passing air. Since this acts by producing eddies, it may be expected to vary as R^2 and R'^2: indeed, Mr. Froude has shown that in the case of water it is as the square of the relative velocity. Here its influence must be very small.

Thirdly. There are two resistances as v^2, which may be grouped together. The first of them is the amount of power expended in throwing outwards the air in the Anemometer's track by centrifugal force, as in a blowing fan; this will be probably as

$$\frac{2Sbv^2}{r}.$$

I measured its amount in quiescent air, by making two cups similar to those of my instrument, and with the same length of arm, revolve with various velocities, by weights acting on a thread coiled on their axles, whose pull at their centres was measured. When the concaves moved foremost, I thus obtained a_{90}; when the convex $a_{90} + b$; and as I had found the ratio of a_{90} and a'_{90} = 4·011, b' was found to be $a'_{90} \times 0, 9535$. Whether it will have the same value in moving as in quiescent air is uncertain; the escape of air against the wind will be impeded, but will be accelerated with it, so that the above mode of computing it may be provisionally assumed.

The other part of this resistance is one arising from the motion of the convexes against the air independent of the wind, which is still more difficult to estimate. At $\theta = 0$ or 180, they move at right angles to the wind, and are resisted as if it were null, therefore as

$$2Sa'_{90} \times v^2;$$

at 90 and 270, this action (as separate from that of V) vanishes; at

* It is possible that eddies from the following convex may reach into the concave, and increase the force.

intermediate positions its amount is doubtful. There will be some due to the component of v perpendicular to V, and some to that part of the convex which is not reached by R or R'.

The combined effect of these and the centrifugal resistance may be put $= Sbv^2$.

Fourthly. The last resistance is friction, which may be of three kinds. It is independent of the relative velocity of the rubbing surfaces, but is as their pressure.

(1). In the ordinary use of the Anemometer, its axis is vertical and the friction due to its weight is constant; this is easily measured by attaching weights to a thread passing over a pulley (whose friction is known), and coiled on its axle or a cylinder fixed on it of known radius $= \rho$, till it just moves on tapping. This weight multiplied by $\frac{\rho}{r}$ is f. (2). The pressure of the wind on the cups is another cause of friction by pressing the axle against the upper bearing. As in permanent rotation the impelling = the retarding forces, and they balance at the axle, the pressure there = their sum, or twice the impelling force. This, as is evident from equation (I.) $= (a - a') \times (V^2 + v^2)$. Let f'' be the friction due to a unit pressure $\perp$ to the axis, then this friction $= 2fa\,(V^2 + v^2)$. The effect of this is simply to substitute for a in (II.) $a\,(1 - 2f_{,,})$. It therefore need not be taken into account, as it will be included in any determination of that co-efficient. The pressure will be something greater than the above from resultants in the direction of the arms, but since these also are as V^2 they do not alter the result. (3). When an Anemometer is carried by a whirling machine, its moveable parts are urged outwards by centrifugal force, which produces pressure on its bearings and therefore friction. Let $f_{,,,}$ be the friction due to a unit pressure parallel to the arm A of the whirling machine; P the centrifugal pressure due to the unit V

$$= \frac{W}{g} \times \frac{G}{A^2},$$

W being the weight of the moving parts, and G the distance of their CG from the centre of the whirler; then $f_{,,,}\,P\,V^2$ is the centrifugal friction; this is equivalent to multiplying a by $(1 - f_{,,,}\,P)$ and need not be computed. But the a ofund by a whirling machine must be divided by this factor to make it apply to real wind measurement. Combining these four forces, and putting for R and R' their values, we obtain for the moving force in the position θ,

$$\frac{F}{\theta} = \left(a_\phi - a'_\phi\right)V^2 - 2Vv\left(a_\phi + a'_\phi\right)\sin\theta - v^2\left(b + a'_\phi - a_\phi\right) - f. \qquad \text{(I.)}$$

If we have a series of values of a_θ and a'_θ through the arcs on which they have positive values, we can get their mean values. For a and a' this value $= \frac{\int_{\theta'}^{\theta''} a d\theta}{\pi}$, θ' and θ'' being the limits between which a is positive; for the second co-efficient it $= \frac{\int_{\theta'}^{\theta''} (a + a') \sin\theta d\theta}{\pi}$.

The integration is easily done by quadratures, and the mean values must be taken, I then gives

$$aV^2 - 2\beta_{,} \times Vv - v^2 \times \gamma - f = 0, \qquad \text{(II.)}$$

which coincides in form with my original equation, the chief difference being in γ.

Adding a second pair of cups at right angles to the former, the forces are all doubled, except f: that is increased by the increased weight of the cups and their arms; but the friction due to the weight of the axle and to the registering apparatus is unchanged. This should always be measured as before described. With four cups the motive force is more uniform than with two, and the period of its variations is half that of the other.

Solving this quadratic, we have

$$V = v\left\{\sqrt{\frac{\beta^2}{a^2} + \frac{\gamma}{a} + \frac{f}{av^2}} + \frac{\beta}{a}\right\} \qquad \text{(III.)}$$

Calling $\frac{V}{v} = m'$; if f were to vanish,

$$m = \sqrt{\frac{\beta^2}{a^2} + \frac{\gamma}{a}} + \frac{\beta}{a}. \qquad \text{(IV.)}$$

This value of m is independent of the size of the instrument, except as relates to the part of γ which depends on centrifugal force, unless it be so small that the impulse on one cup interferes with its neighbour; it is also independent of v. The correction for an instrument which records V as mv is hence easily found; for if $m' = m + \mu$, we have $V = mv + \mu v$; μv is therefore the correction. Now

$$\left(m + \mu - \frac{\beta}{a}\right)^2 = \left(m + \frac{\beta}{a}\right)^2 + \frac{f}{av^2},$$

hence

$$\mu = \left(m - \frac{\beta}{a}\right)\left\{\sqrt{1 + \frac{f}{av^2\left(m - \frac{\beta}{a}\right)^2}} - 1\right\} \qquad \text{(V.)}$$

This decreases as v increases, and vanishes when it is indefinitely increased.

Then comes the question, how are these co-efficients to be determined? Not, I fear, by any observations with actual wind, for none of the methods which have been proposed to measure its velocity are satisfactory. I should prefer determining them by immersing the Anemometer in a stream of water, were it certain that the elasticity of the air makes no difference. But here also the velocity of the current varies in different parts* of its section, and should be meaned through that part occupied by the instrument. Such experiments would be very desirable, when fit opportunity could be obtained; but this is not easily found, and we should, in the first instance, try to get from the whirling machine *its best possible results*, which, I think, with proper precautions, will be far better than those which M. Dohrandt was able to obtain under the conditions of his experiments. I will therefore point out, *first*, the mode in which it and the Anemometer connected with it should be constructed; and *secondly*, the way in which I think it should be employed.

To begin with the whirling machine:—It must combine a strong framing with facility for transport, since it should be used in a room of large dimensions; and such are generally employed for public objects, from which they cannot be long diverted. The framing should therefore be easily taken asunder. I think it essential that the cups in their rotation should not be nearer than ten feet to ceiling, walls, or floor. This, if the arms of the Anemometer be two feet, will require the horizontal arm to be twelve feet from the ground. Its length should be as great as the locality permits, in accordance with the above conditions. If too short, there would be a difference of pressure on the inner and outer sides of the cups, which might disturb the results. I think eight feet would be sufficient. A single arm with a counterpoise alone is required. The arm (and all that it carries) should present as little resistance to the air as possible. That which I used was made of sheet iron ⅛ inch thick, filed to sharp edges, and made inflexible by ties of steel wire attached to the top of the axle. It was only two feet long; but the same construction will be fully available in the present instance. The vertical axle is a tube strong enough to resist the driving force; it turns in collars, one at the top of the frame, another carried by cross-pieces about two feet from the ground. This last has a disc, on which, by means of three balls, or by conical rollers, and a flange attached to the tube, this latter revolves. This perforation of the axle—an idea for which I am indebted to Mr. Grubb—simplifies greatly the mechanism of the apparatus.

A cord passing to the brake-lever of the Anemometer over a pulley at the top of the tube-axle supports an inner tube, adjusted central to it by guides. This tube carries, below the axle, a stage on which cir-

* As to this see page 430, note.

cular weights, up to 10 or 12 lbs., can be placed; below which is attached a conical vessel to receive shot for small additions of weight, which can be removed by a valve at its bottom.

It is important that the machine shall be capable of being driven with a uniform speed of any amount, which can be gradually increased. This may best be effected by the descent of a weight connected with the axle, and continually wound up by means of an arrangement like the well-known contrivance of Huyghens. The velocity can be increased by adding to the weight. At the speed of 25 miles per hour, the maximum resistance to the cups would be about 2 lbs., and the power expended that of 75 lbs., falling 1 foot in a second. This is only ⅜ of a man's power.

The Anemometer to be used in connexion with this machine should also present as little resistance to the air as possible. For this purpose its frame should consist of a strip of sheet iron, twice bent at right angles. The uprights so formed should have bearings for the axle, which must be set parallel to the arm of the whirling machine, and need not be more than 6 inches long and ½ inch in diameter. The cross of the Anemometer is fixed to its outer extremity: this should, in the first instance, be of the Kew type, cups of 9 inches, and the track of their centres 48 diameter. On the axle is secured a brass disk, 6 inches diameter, on whose circumference acts a circular brake, one lug of which is screwed firmly to the bottom of the frame, the other one is pressed towards it by the short arm of a right-angled lever, turning on a centre similarly secured, and its longer arm connected with the cord coming from the whirling machine.* It is evident that by placing weights on the stage, we can apply considerable pressure to the brake, and thus increase the Anemometer's friction without at all interfering with the whirl. Any of these frictions is easily measured. Let the mouth of a cup be horizontal; place small weights at its centre till it just moves on slightly, jarring the frame as by light taps, or drawing a float over it. Repeat this for the other cups, and take the mean. This force is less than what is required to start them from a state of rest, but it corresponds to that which will exist during the rotation of the machine. I expect it will be found that the friction will be constant for a given load on the stage. The centrifugal friction may be determined by attaching to the outer end of the Anemometer axle a thread, pulling in its direction over a pulley of known friction, apply to it a weight $= P$. and measure the friction; the excess of this over the normal friction divided by $P = f_{\prime\prime\prime}$. As it is desirable that the normal friction should be kept as low as possible, the axle should rest on vertical friction wheels, and a horizontal one bearing on the back of the brake disk will lessen the centrifugal one. For a

* Mr. Grubb suggests that the brake apparatus should be brought close to the vertical axis, and the axle of the Anemometer lengthened This would materially lessen the disturbance of air caused by the whirl, and the centrifugal friction.

purpose to be soon mentioned, this disk should have on one face a graduation; to 5° will be sufficient.

Both the whirling machine and the Anemometer should be provided with electric registration in some form. For instance, springs of platinum attached to their axles, and making at each revolution contacts actuating small electro-magnets depressing pens to make dots on a cylinder covered with paper and driven by a clock. Either the cylinder or penholder must have a transverse motion, so that the dots may be arranged in helices if the experiment should last for more than one revolution of the cylinder. If the circumference of the cylinder and the time of its revolution be known, these will probably give the time with sufficient accuracy to compute V. It need scarcely be said that time must be allowed for the whirl to become uniform before the register is made to act.

The most obvious mode of using this apparatus to determine the co-efficients is similar to that used by M. Dohrandt; but using the equation (II.), and measuring f, and obtaining corresponding values of V and v through as wide a range as possible. Then by minimum squares obtain the other co-efficients. I do not like this, because it gives no special information as to the variability of the co-efficients, should it exist; and because since V, except for the very small values of v, is nearly as mv, neither minimum squares, nor common elimination, give accurate results without carrying the calculation to a large number of decimals. The co-efficient a may be determined without difficulty. It $= \frac{f}{V_0^2}$, V_0 being the velocity which just moves the Anemometer from a state of rest. If we increase the speed till it begin to move, we get V_0. This instant may be observed by the dropping of a disk of card, held by friction against a stop, or by employing the electric register of the Anemometer (which is not wanted here), to ring an alarm. One of the cups should be set by means of the graduation on the brake disk to $\theta = 0$, then to 5, 10, &c., to 90; and the mean should be taken through the quadrant to give a. Then the friction should be increased and the a obtained for higher values of V_0. Should these agree with the former, this co-efficient is independent of V; if not, their relation can be found and (II.) modified accordingly.*

As to the other co-efficients, I have already said that the process of minimum squares is not satisfactory on account of the small variation of m' in a series of ordinary observations. But our apparatus enables us by increasing f to increase m' to any extent. Put (II.) in the form

$$am'^2 - 2\beta m' - \gamma - \frac{f}{v^2} = 0. \qquad \text{(VI.)}$$

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* Perfect agreement is not to be expected; for, as already remarked, the velocity of the whirling machine gives only approximately the action of the air on the cups; and the difference will increase with the speed.

Having three such equations with different values of f and v, we can, of course, find the three co-efficients with much greater precision. It is desirable that V should be unvaried for the three observations, to avoid its influence on the result. Here, also, taking V as large as possible, several such triplets may be obtained; and if they all give the same results the co-efficients are independent of v.

Should α be shown by experiment to be constant, the co-efficients $\frac{\beta}{\alpha}, \frac{\gamma}{\alpha}$, are easily obtained; for two of the above equations give

$$\left(\text{calling } \frac{f'}{\alpha v'^2} - \frac{f}{\alpha v^2} = F\right)$$

$$\frac{2\beta}{\alpha} = m'' + m' - \frac{F}{m'' - m'}; \quad \frac{\gamma}{\alpha} = m'^2 - \frac{2\beta}{\alpha}m' - \frac{f}{\alpha v^2}. \qquad \text{(VII.)}$$

If this work should show that additional powers of V or v must be introduced into (II.), m will not be constant, and the instrument should be constructed to show not mv, but v; and a table of V should be computed with v as argument which would serve for all Anemometers of the same type.

Having fully examined this Anemometer, others should similarly be tried, varying in the size of cups and arms; and this will show whether α and γ are exactly as the area of the cups, whether the eddies caused by one cup interfere with the motion of that which follows it, and whether there be any maximum relation between the cups and arms, and how γ varies with the latter.

All this, however, rests on the assumption that the V given by the whirling machine acts similarly to an equal one of real wind. I think that most of the defects of M. Dohrandt's apparatus may be avoided, except the difference between the action of a quiescent and a moving fluid. Yet if this were determined in water for a cup exposed perpendicularly and at 45, for the concave and convex surfaces, it is highly probable that we should be able to reduce with sufficient precision the results of the machine to those of the wind. Should any further experiments like those of Mr. Froude, already referred to, be undertaken, I hope this question will not be lost sight of.

There are two other differences; the Anemometer must produce eddies in the air which in the case of wind are swept away from the instrument; but when it travels in confined space they may continue till in the course of its revolution it returns into them. It is not easy to predict their effect or ascertain how long they last. The circular current established in M. Dohrandt's work will probably (if produced at all) be insignificant in a freer space and better constructed apparatus. It may be best examined by stopping the whirl, and at the instant projecting smoke into the track of the Anemometer. Useful information on this point might be obtained by attaching to the revolving arm a small rectangle of sheet iron inside the Anemometer so as to increase its resistance and observing what change this produces on v.

If we might assume the α observed as above to represent that belonging to real wind (and especially when found with a low velocity of whirl when the eddies must be small), we could obtain β and γ by *its* action. Let the Anemometer above described be detached from the whirling machine and placed in open air with its axle vertical, and near it another as a standard, having its cups and arms of the same dimensions. They will have the same α, β and γ, and the same unknown V may be supposed to act on both.

The observations of v with the two must be synchronous, and calling m' that belonging to the standard, m'' and m''' those belonging to the other with two different values of f obtained by hanging weights to the longer arm of the brake lever, we have, as V is given,

$$m'' = \frac{m' \times v'}{v} = nm'; \quad m''' = n'm',$$

and by (VII.)

$$\frac{2\beta}{\alpha} = m'(n+1) - \frac{F}{m'(n-1)} = m(n'+1) - \frac{F'}{m'(n'-1)},$$

whence

$$m'^2 = \left\{\frac{F'}{n'-1} - \frac{F}{n-1}\right\} \times \frac{1}{n'-n}. \qquad \text{(VIII.)}$$

Knowing m' we have

$$V, \frac{\beta}{\alpha}, \text{ and } \frac{\gamma}{\alpha}.$$

The difference of these values from those given by the whirling machine will show how far the latter method can be relied on in this inquiry.

To avoid the irregularities already referred to as caused by local circumstances, the cups of the two instruments should be at the same height above the ground, their placement should be quite open, and their position occasionally interchanged. But the wind itself is irregular to an extent of which I had no idea till I examined the pressure curves from which I deduced the α of my Anemometer. In one of them whose time was only 99 seconds, the force at the axle varied from 26 to 9 pounds, and in none of them was it nearly uniform. Such variation will affect m' and m'' differently; but possibly the mean results, especially if each experiment lasts for several minutes, will not be much astray.

I think it may be expected, with some confidence, that the line of research which I have indicated will lead to useful results, both in theory and practice, and give values for these constants, which, if not absolutely exact, will be a close approximation to the truth. The experiments which I propose would not be very costly if the apparatus were not constructed for permanent use; and I am not without hopes that I may myself be enabled to execute them.

XL.—The Drifting Power of Tidal Currents *versus* That of Wind-waves. By G. H. Kinahan, M. R. I. A., &c.

[Read November 30th, 1875.]

It might have been supposed that the exhaustive report on Waves, by J. Scott Russell, F. R. S., &c.,* should have decided the relative merits of the tidal currents*† and wind-waves in regard to their drifting powers. This, however, seems not to be the case, if we may judge from the recent paper on the Chesil beach, Dorsetshire, read by Professor Prestwich, before the Institution of Civil Engineers, Feb. 2nd, 1875, and the discussion that followed the reading of it.

In the report above mentioned, Scott Russell divides waves into four orders. To the first of these, or the *Wave of Translation*, belongs the great tidal wave; while wind-waves, according to that observer, with a certain limitation, belong to the second order, the limitation being, that those wind-waves that are in the act of breaking on a beach change into waves of the first order. Indirectly, however, the wind forms a different order of waves, for if water is piled up in a narrow by the wind, the waves induced are "waves of translation." Scott Russell also proves that a wave of the second order has little or no carrying power; consequently wind-waves can have little of this, except when actually running up the beach, when they change to "waves of translation;" and even there their action is limited to a quite narrow line.

In a tideless sea, wind-waves breaking on the coast line form considerable and permanent banks, as in the Mediterranean, where the detritus brought down by the Rhone is piled up during storms on the neighbouring shores, forming banks and lagoons. Considerable wind-wave action also will be found in freshwater lakes and in brackish-water lagoons, if in the latter the cross tides counteract one another; but, as far as my experience goes in the seas round Ireland, the wind-waves do very little permanent work, if unaided by the tidal currents. If wind-waves did effect permanent driftage, it ought to be apparent on the coast lines, the direction of its movement corresponding with that of the prevailing winds resolved along the trench of the coast. The direction of the prevailing winds is always registered by the lean of the trees on a coast line, while the course of the driftage is marked by the sand ridges or banks forming the knee-shaped invers or mouths to the streams, the inver being shifted laterally, in the direction in

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* "Report on Waves," Brit. Assoc. Reports, Vol. xiii. 311, 1844.

† Tidal Currents are due to the "Flow" and "Ebb" of the tides; these are quite distinct from the "Rise" and "Fall" of the tides. This subject is fully explained in the tract on "The Tides and Tidal Currents of the Irish Sea and English Channel," by the Rev. S. Haughton, F. T. C. D., &c., p. 3, *et seq.*

which the driftage tends; but the lean of the trees and the driftage of the beach are often in opposite directions. We also find that a floating body, such as a ship at anchor, always swings with the tide, except in a very excessive gale; and fishermen's nets, when they break loose, always drift with the tidal current; so also floating timber drifts with the tide, unless it comes so near the shore as to be under the influence of the wind-waves, after they have changed into "waves of translation."

The study of the tidal currents on the coast of Ireland teaches us that they have little or no driftage power when the tide is on the ebb, even when confined in narrow channels; to this, however, there are exceptions, as the quantity of water flowing out through a channel may be considerably increased by land drainage, thus causing the efflux to be of longer duration than the influx; in some places the tide runs out of an estuary for hours longer than it flows into it, the efflux being augmented by floods in rivers, and the like. It appears also that the driftage is greater during spring than neap tides; and that the maximum driftage occurs when the direction of the incoming current is the same as that of the prevailing wind. We also learn that the "set" of the tidal current in-shore depends very much on the shape of the coast line. If the coast line is straight, the direction of the set of the tide along the shore, and outside in the deep water, will probably be similar; but if the coast line is indented, or islands lie off the coast, in-shore currents back, or "counter-tides," and cross currents, will be induced, which form off-shore banks, and thus lead to various complications; large rivers may also form counter-currents and off-shore banks.

In a bay, fig. 1, let the normal incoming tidal wave run in the

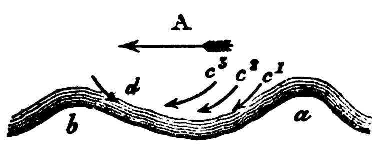

FIG. 1.*

direction of the arrow A; this forms a primary current from the headland (*a*) to the headland (*b*), but from it in-shore or secondary currents branch off into the bay, in the directions of the arrows (c^1, c^2, c^3), which seem to decrease in power from c^1 to c^3; as the flow of the primary current is usually much more rapid than that of the secondary, the tide outside generally comes in faster than in the bay, consequently we often

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* In all the woodcuts arrow A represents the direction of the flow tide, and C the ebb tide—while the arrows B and D mark the directions of effective winds.

find that, towards the end of the flow of the tide, there is a counter in-shore tide from the headland (*b*), in the direction of the arrow (*d*). The figure represents a regular bay, with equal headlands; but in nature we often find the shore line of the bay more or less irregular, or a considerable river flowing into it, which causes various complications in the set of the secondary currents in the bay. Let us suppose one headland to be longer than the other; if the first headland is the longer, off-shore shoals may form across the mouth of the bay, and, after they are formed, the force of the secondary currents seems to increase from c^1 to c^3, fig. 1. The formation of shoals, however, seems to depend also very much on the nature of the rocks forming the sea margin; for if the margin of the bay and the coast up-stream, or in the direction from whence the tidal current comes, are of hard rocks, there may be no materials to form shoals out of; while if the margin of the bay, or even the coast line up-stream, is of frail materials, there will be shoals: a river might, in some places, also bring down materials sufficient to form shoals; this, however, is an exceptional case in Ireland. Or, as in fig. 2, a third headland (*c*) may be opposite the headland (*b*), forming a narrow, as in the English Channel between Portland Bill and Cape la Hogue,* in which case the primary current (A) seems often to strike against the second headland (*b*), while the secondary currents increase in strength from d^3 to d^1. That the secondary currents vary in power, as mentioned above, seems proved, for the following reasons. In such a case as that represented in fig. 1, the beach margining the bay is made up, in nearly all places, of materials very similar, both in quantity and size, which travel round the beach from *a* to *b*; while in such a case as represented in fig. 2, the materials forming the beach

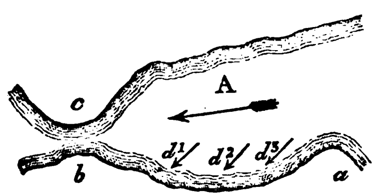

FIG. 2.

increase considerably, both in quantity and size, in the vicinity of the second headland (*b*), while the major portion of them travels across

* Here, in addition to the narrow in the sea, the force of the current is increased as it approaches Portland Bill, by the "Nodal" or "Hinge line" of the Tides in the English Channel, being immediately east of Portland.—(*Haughton, on* "*The Tides*," *&c.*, pp. 22, *et seq.*) To this, thus augmented current, is probably due the assorting and piling of the gravel and shingle of Chesil beach on the east side of Lyme Bay, immediately N.N.W. of Portland Bill.

the bay, and not round its margin; being sorted in their carriage, the largest going furthest, and forming a shingle beach at the back of the second headland (*b*).

Banks off a coast line are connected with counter-currents, but whether such currents have induced the banks or the banks the currents, it is hard to determine. Off a head will be found the end of a shoal, or shoals, and farther up the coast, at a second headland, often very slight, we find that a counter-current has been generated, which flows back along the coast to the first headland, where meeting the current in the opposite direction, both flow seaward, forming a "race," till they meet the "tail" of the shoals. Such races seem seldom, if ever, to form bars or half-tide banks, although they sensibly affect the soundings. The genesis of the "counter-tides" is very obscure, as also the manner in which they finally join into the main tide.

It is not unusual for rocky islands off a coast line to affect the run of the tides. Such islands usually lie off a headland, being a portion of the rocks of the headland, disconnected from it by denudation. Under some circumstances, such an island will split the tidal current, causing a portion on the up-stream side to form a counter-tide that will flow backwards along the coast line; while from the mainland, toward the island, a half-tide ridge often forms. If there are many islands off a headland, the currents may be much more complicated.

Off the inver or mouth of a large river a bank often forms, owing to the driftage of the tide being partially stopped by the water flowing out of the river; let (*b*) fig. 3 represent such a bank.

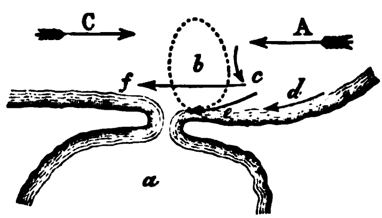

Fig. 3.

In this case, if the bank is only covered during very high tides, when the tide begins to flow into the estuary (*a*) there will be a current running between the bank and the shore, in the direction of (*d*); but after half or three-quarters of the tide has come in, there will be a "counter-tide" in the direction of (*c*); while, after the tide has turned, and the tidal current is running in the direction of the arrow (C), there will be a current into the estuary between the bank and the shore, in the direction of the arrow (*e*); and this latter current will continue until the tide begins to flow out of the estuary, which in some cases (when the estuary widens considerably inside) may be hours after the true turn of the tidal wave. If, however, the bank (*b*) is low, after it is covered (say at quarter or half-tide), the tide will flow over it in the direction of the arrow (*f*), and there will be no "counter-tide" in the direction of (*c*). The "counter-tide" (*c*) has a considerable drifting power; its effects, however, are much modified by the after current (*e*). From this it will be seen that, if the bank (*b*) is only at times submerged, the channel (*e*) between it and the shore will be shallower than if the shoal is covered during the greater portion of the flow of the tidal wave. Other driftages take place in connexion with such a bank; they are, however, usually so slight as not to affect the general question, besides that in a great measure they modify one another.

It has been already mentioned that the unaided outgoing tidal current appears to have little or no drifting power, not even when flowing through a narrow, where we find the seaweed-covered stones are rarely moved. This, however, may be more apparent than real; for if the bottom of a narrow is covered with shingle or coarse gravel, seaweed may grow on these, and prevent them being disturbed; while, if the bottom is small gravel or sand, a portion is carried off by the outgoing tide. It seems, however, to have very little effect on mud, and in the Irish estuaries the detritus brought in, or forced back, by the tide is usually in excess of that carried out. This is very apparent in the tidal flats and banks, where the tributaries of the main stream nearly always flow into it up-stream, as shown in fig. 4, where *b*, *b* are the tidal muddy flats, the arrow A indicates the direction of flow tides,

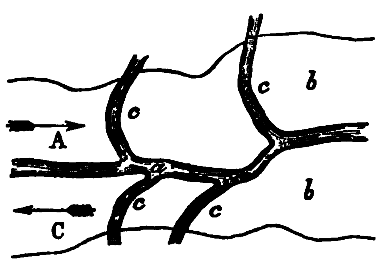

FIG. 4.

and the arrow C the direction of ebb tides—*a* being the stream when the tide is out, into which the tributaries (*c*, *c*, *c*, *c*) enter with the direction of the incoming tide. Even in some places the bed of a large river will be banked up by materials brought up by the tide and the stream forced out of its proper course: for example, the Slaney, Co. Wexford, where, at the point of Park, a mud bank has accumulated, and forced the bed of the river northward. Such tidal accumulations, however, are greatly modified during floods in the rivers, as a large freshet may effect considerable denudation during the time the tide is out. Considerable denudation can also be effected by artificial means; for, by judicious arrangement, as in the Boyne, counties Louth and Meath, the tidal waters can be changed into currents that act like freshets in rivers.

Scott Russell has shown that, at the centre, a "wave of translation" is stronger and swifter than at its margins; somewhat in the same way, the driftage of the in-coming tidal wave off-shore is usually much stronger than it is in-shore. This is a fact well known to the fishermen, who often dredge and fish worked-out ground, rather than fish fresh ground further out, on account of the additional labour that would be incurred in the latter place, consequent upon the augmented velocity of the tides. In-shore, if there is a wide and long shelving beach, the driftage effected is spread over a large expanse, and the results are not very conspicuous or easy to study. This, however, is not the case on quickly-shelving beaches, where the driftage solely due to the tidal wave is conspicuous, as when there is not a breath of wind blowing; if the beach is composed of fine sand or gravel; each wave, according to its intensity, carries up numerous particles in more or less oblique lines. The major portion of the particles go up and come down, as represented by the curved arrows (*g* and *g′*, fig. 5); some, however, re-

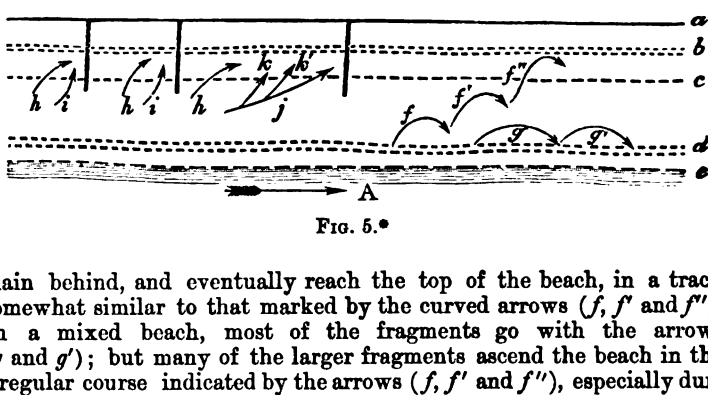

FIG. 5.*

main behind, and eventually reach the top of the beach, in a track somewhat similar to that marked by the curved arrows (*f*, *f′* and *f″*). In a mixed beach, most of the fragments go with the arrows (*g* and *g′*); but many of the larger fragments ascend the beach in the irregular course indicated by the arrows (*f*, *f′* and *f″*), especially during spring tides; these lodge on the top, and form a more or less marked gravelly or shingly margin. It is, therefore, not unusual to find a sloping beach constituted as follows:—Above, at the margin of high-water of spring tides, a more or less well-marked terrace or accumulation of coarse gravel or shingle (*b*, fig. 5); at the high-water of

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* *a* in this figure represents the shore-line, to the left-hand the three perpendicular black lines represent artificial groins.

neap tides, a second (*c*); this, however, is small and temporary, as it is obliterated and removed during springs. Between high and low-water of neap tides (*c* and *d*), there is a shelving beach of gravel and sand, and immediately below *d* is an accumulation of shingle or coarse gravel, forming the base of the steeply-shelving beach; while between the latter and the line of lowest spring tide is a flattish space, often composed of fine, immoveable sand, the outside or lower margin of the regular-moving beach being at the shingle accumulation below the line *d*. On the slope between *c* and *d* there are always more or less large isolated fragments scattered about the surface; the shingle at *b*, except under peculiar circumstances, will ordinarily be much less in quantity than at *d*; the latter moves, more or less, every tide, while the upper accumulation (*b*) only is moved during springs. After storms, however, patches of gravel and shingle will be scattered over the slope between the line *c* and *d*.

This travelling of beaches accounts for the accumulation of shingle on the up-stream side (relatively to the direction of drift movement) of an artificial groin, which stops the travelling of the materials of a beach, as the larger fragments ascending a beach are forced to travel along the courses indicated by the arrows (*h* and *i*, fig. 5), and are prevented from descending by the groins, while the smaller particles are sucked out by the backwash, some accumulates in the space above the arrow (*h*). Or, if the groins are at considerable distances apart, the materials are assorted by the offshoots (*k* and *k*), from the main current (*j*), the larger particles going with the latter. Many natural groins act somewhat similarly, but as some run out into deep water for greater or less distances beyond the margin of the beach, their action is not alike in all cases, as will appear from the following. Usually as a beach while travelling meets with a natural groin (as the headland *a*, fig. 6), the sand, &c., is sucked out to sea in the direction of the arrow (*g*), to be driven into the next bay obliquely (*h*). If, however, the bay (*e*) is narrow and regularly formed, the wash will be directly in and out (*i* and *j*), and in such bays the tidal action seems to tend to accumulate larger beaches than in more open bays. If there is a succession of bays (*d*, *e*, *f*, &c.), with strands, and the headlands between them (*a*, *b*, *c*, &c.) are formed of materials not easily denuded, there will be no source to supply shingle, consequently the materials in the beaches (*k*, *l*, *m*, &c.) will decrease in size from wear, till eventually the beach will be solely composed of fine sand, without shingle or gravel margins, either above or below (*b* and *d*, fig. 5). This refers to the driftage along the margin of the coast; there might, however, be deep sea driftage of coarser material, that would be carried obliquely on to the coast, that may modify the above results; as shingle and gravel often are carried direct from one headland to another, although very far apart.

So far the driftage considered has been that solely due to the tidal currents; their action, however, can be modified or augmented by wind-waves. Wind-waves, as shown by Scott Russell, are usually waves of the second order, and have no drifting power, but locally they may be waves of the first order or "waves of translation;" also, wind may pile up water and form "waves of translation." Thus in a continued heavy gale from the south, the wind will pile up the water in the Irish Sea, to which piling is due heavy large waves that break on the east coast of Ireland. In-coming tidal currents, augmented by the wind blowing in the same direction, are capable of doing the maximum amount of driftage on a coast line, while, if the wind blows adverse to the in-coming tidal current, it modifies the coast work, or even for a time may wholly stop it. Adverse wind and tidal waves pile the gravel and sand on a beach in transverse sloping ridges. If the wind and tide are equal the ridge will be regular; if the tide is greatest, the top of the ridge will slope in the direction the tide is flowing, while the upper end of the ridge slopes with the direction of the wind if the latter is in excess. This ridging of a beach may also occur under other circumstances, for the waves of translation due to the piling of water by wind breaking on a coast line will ridge the beach, also heavy wind blowing against an outgoing tide may force it on to the beach, and piles the latter in ridges. If wind and tidal action are contrary, the maximum power of the wind-waves seems to be during the ebb of the tide, and especially at the low-water of spring tides, when they root up portions of the sea bottom (between *d*, and *e*, fig. 5), that under ordinary circumstances remains undisturbed.

If there are continuous heavy gales blowing obliquely to the in-coming tidal wave (in the direction of the arrow B, fig. 6), accumulations

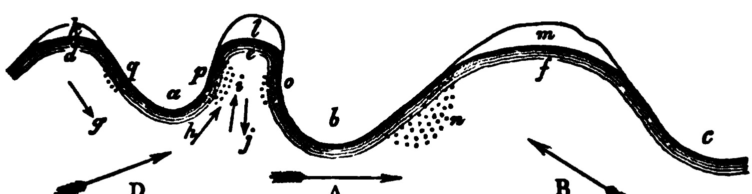

Fig. 6.

of sand and gravel, due to the wind waves, will form at *n* and *p*, while accumulations due to tidal action will collect at *o* and *q*. To form the accumulations at *n* and *p*, continuous gales will be necessary, while a good gale of forty-eight hours' duration in the direction of D will carry them all away; and even this time would not be necessary, but that before the accumulation at *p* can be carried away, that at *q* must be dissipated, for as long as there is any sand at *q*, it will be carried by wind and tide to *p*, and so prevent the latter from decreasing in size.

S.E. COAST OF IRELAND.

To illustrate the foregoing, the following statistics on the south-east of Ireland (Charts xiv. and xv.),* are given, as this coast has been carefully examined, and the results mapped.

The area contained in these charts includes the south coast between Brattan Head and Carnsore Point, and the south-east coast between Carnsore Point and Wicklow Head. On the south coast the normal set of the in-coming tidal current is about west to east, on the south-east coast from about south to north; while on the south coast the more prevailing heavy winds are from about the south-west, and on the south-east coast from about the north-east.† Commencing towards the south-west, we find that at Tramore Bay, the eastward tidal driftage has piled up a ridge enclosing a lagoon called the Back Strand. This ridge having grown eastward, until its farther progress was stopped by the rock-bound coast of Brownstone Head. Such a coast is not easily denuded, and seems to force the driftage seaward in all cases; allowing the mouth of a lagoon or river to remain permanent, the growth of a ridge being thus stopped.

We next meet with the estuary called Waterford Harbour; here a lagoon could not form, for although the eastward driftage has attempted to bar it across, yet on account of the large efflux of water from the Suir, Barrow, and Nore, and the rock-bound shore of Hook promontory, which prevents the channel from moving eastward, the detritus carried in by the tidal wave is carried out again to sea during ebb tides. East of Waterford Harbour is a large bay extending S.W. and N.E., bounded on the N.W. by Hook promontory, and on the S.E. by the Saltee islands and Crossfarnoge Point. Here the main tidal current, when it passes Hook Point sends a secondary current to the N.E. to Bannow Bay; while between Hook and the Saltees, other secondary currents branch off running N.E. to the sound between the north Saltee and the mainland, where they turn to the N.W. into Ballytiegue Bay, forming a counter-tide, which meets the tide from Bannow Bay at the Keeragh islands. The current that

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* Admiralty Chart, Sheet xiv., from Brattin Head to Wexford, surveyed by Commissioner Frazer, M.R.I.A., 1847; and Sheet xv., from Wexford to Wicklow, surveyed by Commissioner Frazer, in 1844, and in part re-surveyed by Staff-Commissioner J. R. Keer, in 1873.

† Winds from the S.W. do not affect the S.E. coast; winds from the south do indirectly, as they pile up water in the Irish Sea, while the winds that blow from the S.E. have the greatest effect on the driftage. On this S.E. coast from Carnsore to Wicklow, the trees lean to the N.E., as the prevailing winds (from the S.W.) have full power across the low lands of the Co. Wexford. Although these winds have such an effect on the trees, they have no effect on the denudation of the coast, the wind-waves generated not acting on this coast line. This accounts for the most effective wind-waves being due to winds that come in an opposite or transverse direction to that of the prevailing winds.

runs N.E. along the Hook promontory carries fragments of the Hook promontory rocks as far as the Keeragh islands; it has also, in part, formed a lagoon occupying the inside portion of Bannow Bay, a considerable ridge of blowing or "Æolian drift" having accumulated as a ridge, extending from the headland N.E. of Fethard. This ridge, however, cannot extend farther, for here, as at Tramore Bay, the opposite coast (Bannow Island) is rock-bound. When this tidal current passes Ingard Point it runs northward to the opposite coast, part from thence going N.E., and part S.W., to the gut called Fethard Bay, the latter current forming a ridge or bar extending toward the S.E. from the north shore of Fethard Bay.

The "counter-tide" which runs N.W. from Crossfarnoge Point has a considerable driftage, and to it in a great measure is due the Æolian sand-ridge, over six miles long, which separates the lagoon* called the Ballyteigue Lough from the open sea. The coast opposite the end of this ridge is of drift, easily denuded, consequently the ridge is yearly extending westward. Since the Ordnance maps were made (1840) it has grown nearly two hundred yards. This seems to be a good example of the effect of tidal currents, pure and simple, as the most continued and effective winds on this coast are from about the S.W., and opposite to the direction of the driftage due to the "counter-tide."

The secondary current which generates the counter-tide just mentioned runs N.E. along the N.W. of the Saltees; but along the S.E. of those islands, there is also a secondary current running in a nearly similar direction; these meet in the sounds, between the islands and the mainland, forming "counter-tides," "races," and half-tide banks: the most marked of the last is called St. Patrick's Bridge, and extends nearly from the mainland, a little east of Crossfarnoge Point, toward the north Saltee Island. Between this bank and Crossfarnoge, at Kilmore, a pier was erected to shelter fishing boats from the S.W. winds; the anchorage, however, is rapidly filling up, on account of the tidal driftage.

In the bay between the Saltees and Carnsore, there are "counter-tides," the most marked being due to an in-shore stream, that runs westward from Carnsore, during three-quarters of the tide, while during the other quarter the current runs to the eastward. These different currents cause a great complication in the driftage, they also seem to assist the wind-waves considerably, as, during storms from the southward, the ridges enclosing the lagoons called Tacumshin and Lady's Island lakes are moved inland, while the coast line in places between Kilmore and Carnsore is being rapidly denuded. South of Tacumshin lake, there is a "counter-tide" running eastward to Kilturk bank; this drifts the bank westward, thus causing the natural embouchure of the lake to be at the western end of the bank,

* This lagoon is now for the most part reclaimed.

as marked in the Chart of 1847. Since then an artificial cut was made, near the centre of the bank, but in subsequent years an attempt was made to reclaim the lagoon, and this cut was replaced by a tunnel. The reclamation and tunnel, however, have failed, and now the natural opening is gradually again forming at the western end of the bank.*

On the S.E. coast between Carnsore and Greenore, the driftage seems to be regularly northward along shore; but after the latter point is passed there are two lines of driftage, the main driftage direct towards Cahore Point, and a secondary driftage round Greenore Point, and along the shore of Ballygeary Bay to the Dogger bank. There is also at times, in all the bays on this S.E. coast, a driftage direct on shore, occurring after continuous south gales, and apparently due to the water being banked up in the Irish Sea by the wind. That the two first mentioned tidal driftages occur is quite palpable, as portions of the rocks forming the coast at Carnsore and Greenore are found along the shore of Ballygeary Bay as far as the Dogger bank, also in the shingle beach which margins the coast for three miles on the south of Cahore Point, while between the Cahore shingle beach and the Dogger bank they are very rare. Such pieces must come from Greenore, and not from the local drift, as all fragments and blocks in the drift have come from the northward or north-eastward, and not from the southward. If we trace the beach driftage from Greenore we find in various places along the shore a little shingle, which increases in quantity and size as we approach the Dogger bank; on to which, and from its N.E. end north-eastward to the Blackwater bank, in the deep water, most of it seems to be carried. Some, however, goes through the Hantoon channel, between the Dogger bank and the Rosslare sand ridge, a small portion of which is carried round the north end of that ridge, to be lodged on its west side. In Ballygeary Bay, a pier and viaduct was commenced in 1873. This has now quite changed the features of the coast-line on the east of the pier, as a foreshore has formed between the old cliff and the sea. This accumulation extends from the pier to the Point of Ballygillane, is over 100 yards wide, and in places over eight feet deep.

The efflux from the Wexford lagoon stops the tidal driftage to the northward, and thus forms the Dogger bank; and formerly, prior to the in-take of a considerable portion of this lagoon, this driftage accumulated in a massive, irregular east and west tidal shoal, as represented in the chart made in 1847 by Comm. Fraser, R. N.;† showing that the force of the efflux and of the tidal wave was nearly equal.

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* Since the above was written, the occupiers of the adjoining lands have cut the bank near the former artificial embouchure.

† Admiralty Chart, Sheet xiv., A. D. 1847, which compare with the bank as marked on Sheet xv., A.D. 1873, and enlarged plan Wexford Harbour, A.D. 1847, and Wexford Harbour, A.D. 1873.

Now, however, the force of the efflux is much less, and the Dogger bank has changed into a long, narrow N.E. and S.W. shoal,* considerably overlapping the mouth of the estuary and the end of the Raven ridge. This shoal is gradually accumulating, so that now there is a long, narrow N.E. and S.W. island formed. The change in the efflux from the Wexford lagoon has not only affected the Dogger bank at its immediate embouchure, but also the off shore shoals; as when the current from Wexford harbour was pushed northward, the Lucifer shoal began to be denuded, and is now gradually wasting away: the outline of the Blackwater bank is also changing. The present Dogger bank also forms a half-tide "counter-tide," running to the S.W., which strikes on the Rosslare ridge, and is rapidly cutting a passage through it. On account of the present currents and driftage, the passage and bar of Wexford harbour are ever changing; this, however, could be materially prevented by an artificial regulation of the currents, and consequently of the driftage.

Between the North bay and the Cahore shingle beach there are high drift cliffs, which are weathering rapidly, as high tides wash their base; some of this drift is very stony, but the stones out of it do not form a shingle beach at the base of the cliff, but are sucked out seaward to low-water of neap tides (*d*, fig. 5), along which line they are drifted northward, some of them eventually to be cast up to augment the Cahore shingle beach. In the neighbourhood of Cahore Point there is a slight "counter-tide," in connexion with the shoals called the Rush bank and the Ram; this forms a race called the "Sluice of the Ram." This counter-tide slightly affects Cahore shingle beach, on which account the largest fragments are not found at its northern end.

The Cahore shingle beach margins a ridge of Æolian sand, and when the sea was at the height of the present Ordnance twenty-five feet contour line, there was an island at Cahore Point having a considerable sheet of water to the S.W. of it; this was subsequently a peat bog, when the land was about thirty feet higher than at present; afterwards a lagoon, separated from the sea by a ridge, and now it is all more or less reclaimed. At first, to drain it, a canal was made through the centre of the ridge on the S.W. of Cahore Point. This, however, was always being filled by the driftage from the south, and now the tract is drained by a canal which empties itself into the sea through a culvert in a pier that has been built at Pollduff, a little N.W. of Cahore Point. This canal, unfortunately, is not effective, on account of the site of the pier; opposite to the mouth of the culvert is a breakwater, behind which the sand collects and dams up the water; and between the Point and the pier is a bay, in which the driftage collects: this, during N.E. winds, which are those that most prevail at

* Admiralty Chart, Sheet XV., 1873, and enlarged plan Wexford Harbour, A.D. 1873.

the time the canal ought to be acting, causes the pier to be silted up by sand and gravel. Here the sand and gravel, collected during months by the N.E. winds, will be carried away by one good continuous gale during spring tides from the S.W. A short gale would do the work, were it not for the sand in the bay between the pier and the Point, this having first to be removed, as otherwise the tidal driftage from the south will replace the sand on the north of the pier as fast as it is removed.

From Cahore to Kilmichael Point, the driftage seems to be in general even and regular, its direction being to the northward. Between these two points is Courtown, on the Owenavorragh river, where piers and other works have been constructed, but unfortunately, the harbour is almost useless, as its embouchure is nearly always silted up. Here, also, is an example of the superior driftage power of the tidal currents over the wind-waves. Some years ago, a storm swept away the end of the south pier, after which the N.E. gales used to clear out the bar in the mouth of the harbour, but lately the end of the south pier was rebuilt, since when similar gales do not clear the bar. The reason for this is quite apparent, as, prior to the end of the south pier being rebuilt, gales from the N.E. excavated out, not only the accumulations forming the bar, but also the accumulations between the piers and the headland (Breanoge Head), a little to the south; now, however, such gales can only affect the bar, the south bay being protected from their influence; consequently, as fast as the bar is removed, the tidal driftage replaces it with other materials. This place seems to be more favourably situated for the construction of a harbour than any other on the S.E. coast, if the driftage was taken into consideration and provided against.

A mile due east of Kilmichael Point, is "the tail" of the Glassgorman bank, and in a nearly east and west line between them is the "race of Kilmichael." This is due to the tide from the south here meeting a counter-tide generated near Arklow Head. Immediately north and south of Kilmichael promontory, as in many other places on this coast, there were in years gone by considerable bays, which have been since filled up by accumulations, principally of Æolian sand, while of late years these sand hills have been considerably denuded at their southern ends. In the bay to the south of Kilmichael, over thirty-five acres in area have been carried away since the Ordnance maps were made (1840), and in that to the north about thirty acres.*

In the tract to the south of Kilmichael, the encroachments on the Æolian drift only take place during gales from the S.W. This is, as might

* There are no reliable records prior to the Ordnance Survey, but the old men remember when the land extended much more seaward than is indicated by the Ordnance maps. In confirmation of their statements, they point to the old roadways, which now lead to nearly perpendicular cliffs.

be expected, the wind action being combined with the tide, and thus creating an increased driftage; but in the tract to the north, the wind-waves act against the driftage of the "counter-tide;" yet the principal denudation is at the south end of the accumulation, and what apparently is more remarkable, immediately to the northward, between Clogga and Arklow Head, there is another similar accumulation of Æolian sand, where the principal driftage is not northward with the wind-waves, but southward with the counter-tide. This exception in the bay between Clogga and Kilmichael is the only place on the whole of the coast line in these charts, where the drifting power of the wind-waves seems to exceed, or even equal, that of the tidal current; possibly, however, this apparent anomaly may be due to the tides during springs running direct on to the coast hereabout, from "the tail" of the Glassgorman bank; but in support of such a supposition I could get no evidence. Under ordinary circumstances, the driftage hereabouts seems to be southward with the "counter-tide," as the fragments of the rocks are carried south along the beach.*

North of Arklow Head, opposite the valley of the Ovoca river, there was formerly a large Æolian sand accumulation enclosing a lagoon, and from what now remains it is evident that formerly the driftage from the southward shifted the embouchure of the Ovoca river somewhat northward; now, however, by piers and other artificial means, an entrance has been made and kept open near the centre of the sands. Here also, as at Pollduff and Courtown, the works have not been efficient. Formerly, N.E. gales cleared out the bar, but of late years the south pier was lengthened, which has had the same effect (and for a similar reason) as the rebuilding of the south pier at Courtown, previously mentioned.

From Arklow to Mizen Head, and from that to Ardmore Point, the tide and driftage seem very regularly northward. In the different bays, in all of which there are Æolian sands, the tide cuts a little from the southern extremities of the banks, while more or less is added to the north end; except in Jack's Hole, where the bank has been added to considerably all along. Here it may be mentioned, that on this coast the outer margin of the sand hills is now generally more regular than when the Ordnance maps were made, in general all the jutting out portions having been cut away, or the hollows filled up.

Between Ardmore and Wicklow† there are various complications on account of the points and shoals that generate "races" and "counter-tides." Of these "counter-tides" the larger one begins near Five

* These "counter-tides" seem to have been very little studied, and are not marked on the chart. Neither the coastguards nor the fishermen seem to be perfectly acquainted with them. They all know the ordinary "set," and allow that this at times changes, but the exact time of the change, and the cause of it, they cannot tell.

† Wicklow is situated immediately outside the north margin of the area included within the limits of the Chart, Sheet xv.

mile Point,* on the north of Wicklow, and flows southward to Bride Head, off which there is a considerable "race." This "counter-tide" drifts the beach southward, and thereby has formed a shingle and gravel ridge, which has pushed the Vartry southward, until its farther progress in that direction was stopped by the hard rocks that form the Wicklow Head promontory, the pent up waters forming a lagoon and marshes. Here, at the south end of the ridge, the driftage seems to be carried to sea; for, as in other places where a rock-bound coast stops the further growth of a ridge, the embouchure out of the lagoon seems to have a permanent bar: but, what here appears remarkable, this bar has not changed during late years, although half the waters that used to come down the Vartry are now diverted to supply Dublin.

These notes record what has been going on during late years, but it has to be remembered that, during comparatively recent years, large bays existed, that are now filled up with Æolian sand.† Why the sand banks accumulated in these bays seems to be due to a slight rise in the height of the land, as, when the sand has been removed by wind, ancient sea beaches are found under them. If, therefore, their accumulation was due to a rise in the land level, it appears probable that in those places where the sand banks are now being denuded, there must be a slight fall going on in the level of the land. The difference, however, in the levels is so slight that changes in the height of the Rise and Fall of the tide (Full and Change), possibly, might account for the denudation, without the level of the land changing.

RESULTS.

The information gathered on this portion of the coast of Ireland goes to prove the following:—

First.—The driftage due to the incoming tidal current is always, during its progress, going on in deep water, and more or less in shallow water.

Second.—The driftage due to wind-waves only occurs during gales, and even then is only due to the waves that break on the shores.

Third.—To prevent the tidal driftage (arrow A Fig. 7), groins, or piers, should be erected; and if the pier (*b*) is to form a harbour (*f*), transverse groins (c c^1) should run out from it, to stop the back wash generated by the pier, for otherwise this back wash would carry the driftage seaward, in the direction of the arrow (*d*), to be sucked round the pier into the harbour (*f*).

Fourth.—As the wind-wave driftage occurs during gales, and then only on the shore line, it might be prevented from filling up a harbour,

* Admiralty Chart, Sheet xvi.

† About a mile S.S.W. of Kilmichael Point, the writer was shown a rock cliff, recently exposed by the denudation of the Æolian drift, that, prior to the accumulation of the latter, seems to have been quarried by man.

or damaging the shipping in it, by placing a breakwater (*e*, fig. 7) across the direction (*arrow* B) from which the prevailing storms come.

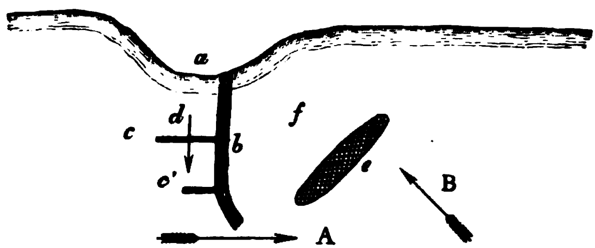


Fig. 7.

If such a breakwater were a fixed one, built of stone or wood, it must more or less affect the tidal driftage, and probably would help to fill up the harbour. But if it was floating, it ought to break the wind-waves in deep water, thus destroying their drifting powers, while there would be no impediment to interfere with the tidal driftage. The exact form of the pier, whether straight, or slightly curved, as represented in the figure, would have to be determined on, after experiments on the sets of the currents, at the place where the pier was to be built.

XLI.—AN ESTIMATION OF THE FREE AND ALBUMINOID AMMONIA YIELDED BY THE STAGNANT WATERS OF THE DUBLIN STREETS, AS COMPARED WITH THE QUANTITIES OF THOSE SUBSTANCES OBTAINED FROM THE LIFFEY WATER, AFTER RECEIVING THE SEWAGE. By LANCELOT STUDDERT, LL.D., EX-S. T.C.D.

[Read 10th January, 1876.]

DURING the Session of 1874–5 of the Royal College of Science, Stephen's-green, several examinations were made there of Dublin well-waters; and also some determinations like those that follow for the river water. As a sequel to those analyses, the suggestion of the Professor of Chemistry in that college, Mr. Galloway, induced me to undertake a series of estimations of the ammonia yielded by the surface-water of some streets and squares in Dublin, taking as the standard of comparison the water of the Liffey, near where the sewage is discharged into the river.

The results of my examination, conducted during November and December last, in the College of Science Laboratory, are now laid before the Royal Irish Academy.

Altogether twenty-nine of these street waters were examined: the samples dealt with were collected, in my presence, at the times and places stated in the Table appended to this paper: the mud, also, left from some of these pools, was examined for ammonia, which reached two parts in the hundred, calculated after allowing for moisture expelled at 212° Fahrenheit. The river water was collected at intervals during the two months, from four different places, namely, at Eden-quay, Aston's-quay, Burgh-quay, and Sir John Rogerson's-quay, four hours after high water at Dublin bar.

The method employed for determining the quantity of ammonia yielded by these waters and muds is that devised by Messrs. Wanklyn and Chapman. This process is almost universally allowed to be the best yet made known for ascertaining the character of the nitrogenous matter in waters; its quantitative results are accurate, and they are obtained with rapidity. It may be well to state, for the information of any unacquainted with the Wanklyn and Chapman process, that under the term "*free ammonia,*" these chemists include ammonia not only present *as such*, or in combination with acids, but also the ammonia that, after adding a saturated soda carbonate solution, is evolved by distillation from urea, or other easily decomposable nitrogenous organic bodies. The term *free ammonia* is therefore not strictly correct; but, taking it in this special sense, it would be difficult to substitute any other term more convenient, or less open to objection.

The Table of results gives the figures for the Liffey standard at the head of the list. The quantities of the free and the albuminoid ammonia obtained from the several street and Liffey waters are calculated as grains in the gallon, and also as milligrammes in the litre of each water, respectively, examined.

The average of free ammonia from the four samples of the river is 0·0982, or under $\frac{1}{10}$ of a grain in the gallon; the average of albuminoid ammonia from the same is 0·0779, or under $\frac{1}{12}$ of a grain in the gallon.

It may be interesting to note that the examination of the river water referred to as having been made by other workers in the College of Science Laboratory in 1874, gave a result equal to my average in 1875: thus shewing a remarkable constancy in the state of the Liffey.

It may also be remarked in passing that my average for free ammonia is less, but for albuminoid ammonia is greater, than the average Messrs. Wanklyn and Chapman reported as that of the Thames at London-bridge, in June, 1867: that river, the tide being at two hours flood, yielding free ammonia = 0·1232 of a grain per gallon; and albuminoid ammonia = 0·0245 of a grain to the gallon.

The average of free ammonia obtained from the 29 street waters is 17 grains to the gallon; that is, over 170 times the like average from the river. The average of albuminoid ammonia from the street water is 3 grains to the gallon, or 38 times the Liffey average.

It will be seen by the Table, that from three out of the four river samples, the quantity of free ammonia was under that yielded by any of the street waters, except at Stephen's-green, East and South.

The maximum of free ammonia from the river was at Burgh-quay, and only reached 0·175, or less than $\frac{1}{5}$ of a grain to the gallon; whilst the maximum of free ammonia from the street waters, namely, at Moss-street and Poolbeg-street, was 105 grains to the gallon, that is exactly 600 times greater than the river maximum.

The *least* impure of the 29 street waters yielded nearly three times more albuminoid ammonia than the *most* impure sample of the river water; for instance, the surface-water at Merrion-square, South, being the best of the street waters, yielded 0·280 of a grain, against that obtained from the river at its worst, namely, 0·098 of a grain, or nearly 3 to 1.

But the bad preeminence of the water in Moss-street and at Peter-place (corner in Adelaide-road), and in Lee's-lane, off Aston's-quay, namely, 10 and 10·15 and 11·2 grains of albuminoid ammonia from one gallon of each water, respectively, is more than 100 times greater than the Liffey maximum.

Messrs. Wanklyn and Chapman conclude from a wide induction of experiments that "the disintegrating *animal refuse* in the river [Thames] would be pretty fairly measured by *ten times* the albuminoid ammonia which it yields." In this way, the average of such refuse in the Liffey is 0·779, or just $\frac{3}{4}$ of a grain in the gallon; whilst the average of such refuse in the street waters is 29 grains to the gallon.

That much of this enormous amount of animal matter thus in our midst must, if not rapidly removed, take forms that will vaporise, seems all but certain, since the conditions for spontaneous decomposition may be said to be always present: there are the moisture and heat required for this chemical change, and then there occurs at intervals the drying up of these stagnant pools.

My examination of these street waters found, as might be expected, sulphuretted hydrogen, with other sulphides and very offensive volatile substances.

What the effect must be on the people's health who dwell in an atmosphere contaminated by exhalations such as these, it is not for me to determine; this paper simply records the facts of the case, leaving conclusions to those physicians who make such researches their peculiar study. But without knowing the least of the little that is known, even to the medical faculty, about either the chemical or the germ-theory as to the propagation of disease, yet one of the unlearned, like myself, having but ordinary sagacity, might correctly conclude that the continued presence of so much dirt in the streets would go far to account for the high death-rate (33 to the 1000, yearly) lately recorded for Dublin; a city whose situation, other things being equal, might mark it out as one of the healthiest in the Empire. The London "Times," last week, reviewing "Ireland at the close of 1875," laid this to our charge—that "dirt reigns, and slays its thousands in Dublin and elsewhere."

Whatever is to be done with our street sewage, whether it is still to defile the natural purity of the river, or to be applied to improve the land, or only to be thrown away, with great cost, into the sea; whatever be the destination of this noxious mass, whether it is to be good, bad, or indifferent, it certainly appears, from the results now laid before the Academy, that better scavenging and a level surface for the streets is at once required.

The Professor of Hygiene and Public Health in University College, London (Dr. Corfield), in reference to this subject, in the "Manual of Public Health," edited by Hart, states that:—"If the streets, roads, and ways of a town or district are allowed to become or to remain so out of repair as to become receptacles for filth, or to afford, by their inequalities, depressions in which foul water accumulates, it is in vain to look for beneficial results from other sanitary measures."

TABLE OF RESULTS.

Date of collection of water.	Place of collection of water.	FREE AMMONIA.		ALBUMINOID AMMONIA.	
		Grains per gallon.	Milligram. per litre.	Grains per gallon.	Milligram. per litre.
1875.	LIFFEY STANDARD.				
November 11,	Eden-quay,	0·0840	1·20	0·0980	1·40
" 29,	Aston's-quay,	0·0812	1·16	0·0910	1·30
December 15,	Burgh-quay,	0·1750	2·50	0·0875	1·25
" 17,	Sir J. Rogerson's-q.	0·0525	0·75	0·0350	0·50
	Total =	0·3927	Total =	0·3115	
	Average =	0·0982	Average =	0·0779	

TABLE OF RESULTS—*continued.*

Date of collection of water.	Place of collection of water.	Free Ammonia.		Albuminoid Ammonia.	
		Grains per gallon.	Milligram. per litre.	Grains per gallon.	Milligram. per litre.
1875, Nov. 1,	Stephen's-gr., N.,	0·126	1·8	0·238	3·4
" 2,	" E.,	0·070	1·0	0·420	6·0
" 3,	" S.,	0·070	1·0	0·378	5·4
" 5,	" W.,	0·315	4·5	0·490	7·0
" 15,	Stephen-st., lower,	12·600	180·0	5·800	80·0
" 17,	Cross Kevin-st.,	2·800	40·0	1·400	20·0
" 18,	Patrick-street,	4·900	70·0	1·750	52·0
" 19,	Townsend-street,	4·550	65·0	4·900	70·0
" 20,	Peter-place, at corner on Adelaide-road, . .	5·600	80·0	10·150	145·0
" 30,	Baggot-st., lower,	0·700	10·0	0·800	12·0
December 1,	Duke-lane, . .	1·190	17·0	1·190	17·0
" 1,	Lemon-street (late Little Grafton-st.),	9·100	130·0	2·030	29·0
" 2,	Leeson-st., lower,	1·540	22·0	0·910	13·0
" 2,	Leeson-lane, . .	10·500	150·0	2·380	34·0
" 7,	Creighton-street, .	1·540	22·0	0·980	14·0
" 7,	Sandwith-street, .	1·820	26·0	1·400	20·0
" 7,	Boyne-street, . .	4·200	60·0	2·110	31·0
" 8,	Abbey-street, Mid.	3·780	54·0	1·820	26·0
" 10,	Lees-lane, Astons'-quay, ...	98·000	1400·0	11·200	160·0
" 10,	Sir J. Rogerson's-quay, *Gutter*, .	70·000	1000·0	7·000	100·0
" 10,	Moss-street, . .	105·000	1500·0	10·000	145·0
" 10,	Poolbeg-street, .	105·000	1500·0	7·000	100·0
" 14,	Peterson-lane, .	9·800	140·0	0·980	14·0
" 15,	Frederick-lane, S.,	7·000	100·0	1·820	26·0
" 17,	New-street, . .	13·500	150·0	3·500	50·0
" 20,	Fitzwilliam-sq., W.	0·490	7·0	0·350	5·0
" 20,	" " E.	17·500	250·0	1·750	25·0
" 20,	Merrion-sq., N., .	0·350	5·0	0·525	7·5
" 20,	" " S., .	0·420	6·0	0·280	4·0
	Total =	492·861	Total =	83·646	
	Average = 17 grs. of free ammonia per gallon of water (surface).		Average = 3 grs. of albuminoid ammonia per gallon of water (surface).		

Mud dried at 212° *F.*

	Percentage.—Free Ammonia.		Albuminoid Ammonia.
Peter-place corner,	1·2857	+	0·6163 = 2 p. c.
Lower Stephen-street,	0·3780		0·1001
Boyne-street,	0·4861		0·3640.

XLII.—ON AN ELEMENTARY PROOF OF "LAGRANGE'S EQUATIONS OF MOTION IN GENERALIZED CO-ORDINATES." By ROBERT S. BALL, LL. D., F. R. S., Andrews' Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland.

[Read 24th January, 1876.]

THE proofs generally given of these most useful equations depend upon D'Alembert's principle. It is possible that these equations would be more used, even in elementary Dynamical problems, if the method of establishing them were simplified. I can hardly believe that the proof here given is new; but I have read altogether seven proofs in seven different books, and of these, five depend upon D'Alembert's principle, while the two remaining ones have little or nothing in common with the method I here give.

Let V denote the potential energy of a Dynamical system, and T the kinetic energy. Let q be one of the n generalized co-ordinates by which the position of the system is specified.

Suppose the system receive a displacement δq: then the particle of mass m, of which the co-ordinates are x, y, z, receives a displacement, of which the components are

$$\frac{dx}{dq}\delta q, \quad \frac{dy}{dq}\delta q, \quad \frac{dz}{dq}\delta q.$$

The forces acting on m, at x, y, z, are

$$m\frac{d^2x}{dt^2}, \quad m\frac{d^2y}{dt^2}, \quad m\frac{d^2z}{dt^2}.$$

Hence the quantity of work done, while the displacement δq is made, is

$$\Sigma m\delta q\left(\frac{dx}{dq}\cdot\frac{d^2x}{dt^2}+\frac{dy}{dq}\cdot\frac{d^2y}{dt^2}+\frac{dz}{dq}\cdot\frac{d^2z}{dt^2}\right),$$

the symbol Σ extending to all the particles of the system.

The potential energy of the system is therefore diminished by this amount, whence

$$-\frac{dV}{dq}=\Sigma m\left(\frac{dx}{dq}\cdot\frac{d^2x}{dt^2}+\frac{dy}{dq}\cdot\frac{d^2y}{dt^2}+\frac{dz}{dq}\cdot\frac{d^2z}{dt^2}\right).$$

We have also

$$T=\tfrac{1}{2}\,\Sigma m\left\{\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2+\left(\frac{dz}{dt}\right)^2\right\},$$

whence

$$\frac{dT}{dq} = \Sigma m \left(\frac{dx}{dt} \cdot \frac{d^2x}{dtdq} + \frac{dy}{dt} \cdot \frac{d^2y}{dtdq} + \frac{dz}{dt} \cdot \frac{d^2z}{dtdq} \right).$$

Suppose the other generalized co-ordinates be r, s, &c., then we have

$$\frac{dx}{dt} = \frac{dx}{dq} \cdot \frac{dq}{dt} + \frac{dx}{dr} \cdot \frac{dr}{dt} + \frac{dx}{ds} \cdot \frac{ds}{dt} + \&c.$$

$$= \frac{dx}{dq} \cdot \dot{q} + \frac{dx}{dr} \dot{r} + \frac{dx}{ds} \dot{s} + \&c.$$

whence

$$\frac{d}{d\dot{q}} \left(\frac{dx}{dt} \right) = \frac{dx}{dq}$$

We therefore have

$$\frac{dT}{d\dot{q}} = \Sigma m \left\{ \frac{dx}{dt} \cdot \frac{d}{d\dot{q}} \left(\frac{dx}{dt} \right) + \frac{dy}{dt} \cdot \frac{d}{d\dot{q}} \left(\frac{dy}{dt} \right) + \frac{dz}{dt} \cdot \frac{d}{d\dot{q}} \left(\frac{dz}{dt} \right) \right\},$$

$$= \Sigma m \left(\frac{dx}{dt} \cdot \frac{dx}{dq} + \frac{dy}{dt} \cdot \frac{dy}{dq} + \frac{dz}{dt} \cdot \frac{dz}{dq} \right),$$

whence by differentiating,

$$\frac{d}{dt} \left(\frac{dT}{d\dot{q}} \right) - \frac{dT}{dq} = - \frac{dV}{dq}.$$

The remaining $(n - 1)$ equations are to be similarly proved.

XLIII.—ON THE EXPLORATION OF THE KNOCKNINNY CAVE. BY T. PLUNKETT. WITH AN ACCOUNT OF THE ANIMAL REMAINS. BY REV. Professor HAUGHTON, M. D., F. R. S., and Professor MACALISTER, M. D.

[Read 24th January, 1876.]

THROUGH the pen of Mrs. Hall, as well as some other writers, who were less graphic in their delineations, Lough Erne is far-famed for its beautiful and varied scenery, combining almost everything that is lovely and picturesque in nature—the very sight of which is calculated to produce the "joy of elevated thoughts," and inspire feelings that only a Wordsworth could adequately pourtray.

In an archæological point of view, it is also very interesting, as, scattered round its shores and some of its numerous islands, there are a number of rude stone monuments, of unknown antiquity. There are also numerous remains of an early Christian people, who must have attained a high level of culture and civilization, as the architecture of their churches and monasteries—even in their hoary ruins—testify, together with the round tower of Devenish Island, which is one of the finest in Ireland; but, according to Mr. Bourke's theories, enunciated in his late work (Aryan Origin of the Celtic Race), the round towers must be removed from their recognised place in the architectural history of the country, and pushed back into the dark mysterious past, or pre-Christian times.

The cave, and its interesting contents, the subject of this paper, add a new feature to the antiquities found in the valley of Lough Erne, and probably, in some respects, it is unique in Europe. As far as I can ascertain, the large cinerary urn (fig. 7), which I found in an upper stratum of the cave-earth, containing burnt human bones, is the first of this kind found in any cave in Europe.

Knockninny, the name of the rocky hill where the cave occurs, rises abruptly on the southern shore of Upper Lough Erne, ten miles from Enniskillen, and two from the village of Derrylin. Its elevation is neary 700 feet above sea level; and, speaking in the language of geologists, was recently an island. It is bounded on the north-east side by the waters of Lough Erne, and south-west by a flat alluvial plain, including some patches of bog.

On approaching the hill by the road from the west side, it presents a bold and majestic appearance, calculated to inspire feelings of awe. Owing to these natural features, probably, the early Pagans regarded it as a sacred spot, and chose it as the last resting-place for their departed chiefs, and not of one alone, but of several tribes, as we may infer from the fact that three different modes of sepulture are found on its summit, including the cinerary urn found in the cave.

On three rocky hillocks, at intervals along its top, there are three Pagan carns, and one of them the finest in Fermanagh. By accident, when the owner of the place was making a deep ditch along the south side of this carn, he disentombed two ornamented urns, containing burnt bones. On its eastern slopes there are two "giants' graves," one of which I assisted Mr. Wakeman to explore. It was an oblong square, formed of rough limestone flags, set on edge, and measured about 17 feet long, and 4 feet broad; it yielded human bones, mingled with those of animals. There were traces of charcoal round the margin of the grave. It was Mr. Wakeman's opinion, from the presence of the charcoal and animal remains, that they had funeral feasts at the time of burial.

The top of the hill is about half a mile broad at its widest diameter. A county road encircles its base, and is united by a short junction to the road leading from Enniskillen to Derrylin.

The hill commands one of the most magnificent and comprehensive views to be obtained in the fifty-two miles of country through which Lough Erne passes. Standing on its top, and looking towards the north on the opposite side of the lake, there appears, sequestered in a shady nook on the wooded island of Belleisle, the square tower attached to the residence of J. G. V. Porter, Esq., and lately occupied by the Earl of Rosse; and on the same spot, during the fourteenth century, Charles Maguire compiled one of the best collections of the annals of Ireland, which are known as the Annals of Ulster (Wakeman's Guide to Lough Erne). Looking to the west, about four miles distant, the eye rests on the palatial residence of the Earl of Enniskillen, situated at the base of Benaughlin mountain. Eastward, in the dim distance, may be recognised the last of a group of mansions which stud the shores of Upper Lough Erne in this locality—I mean the seat of the Earl of Erne, contiguous to which the old ivy-clad Castle of Crom, which stood many a hot siege, raises its roofless but venerable walls.

Mr. Porter, whose residence I have described, is owner of a large portion of Knockninny hill, and has built a neat hotel at its base on the shore of the lake. Were it not for his enterprising and generous spirit, the public would have no means of visiting the scenery and antiquities of Lough Erne, as he, at considerable expense and pecuniary loss, keeps a neat steam-boat on the lake for the accommodation of tourists. But for this gentleman Knockninny cave would probably still remain unexplored. During the month of June last I had been exploring some caves in the mountains west of Enniskillen, when I happened to meet Mr. Porter, and had some conversation with him on cave-hunting. He at once asked me to make a preliminary inspection of the "fox cave" at Knockninny, and ascertain if it was worth exploring, proposing at the same time to supply any labourers I might require. I at once accepted his kind offer, and on a convenient day visited the cave, bringing with me two labourers who were in Mr. Porter's employment, working in a quarry at Knockninny.

The cave penetrates an escarpment in the south-west side of the hill, and has an altitude of about 330 feet above the adjoining valley. Leaving the road in the valley which surrounds the base of the hill, we ascended a steep acclivity towards the east entrance of the cave, which opens into an indentation in the face of the rock (fig. 1). On reaching

Fig. 1.

it I made a careful examination of the rock adjoining the entrance, and found that through atmospheric agencies several feet at the entrance had crumbled away. Seeing this, I ordered the men to commence digging on a grassy slope, fully six feet outside the door of the cave. After removing a quantity of *debris*, and blocks of stone, we found charcoal, some human remains, also bones of animals. Digging a little deeper, the original floor of the cave was laid bare—I mean when it extended nearly six feet further out. After clearing away this accumulated stuff towards the entrance, I found from the depth the cave-earth presented, when we had penetrated a little inside, that, although the cave appeared small, yet when excavated, it

Fig. 2.

would be a considerable size, as it contained such a quantity of cave-earth. Having obtained a vertical section at the mouth of the cave, 4 feet deep, and finding the remains above mentioned, I came to the conclusion that it would repay the trouble of exploring, as I conjectured from what I found that it would yield interesting relics. Without further delay I decided on making the necessary arrangements to have it thoroughly explored.

It being on the property of Lord Erne, this nobleman, on being asked, kindly gave permission to have it examined.

Having provided crowbars, picks, and buckets, we set to work; and before giving a detailed account of the exploration, I should state that the cave passes (fig. 2) into the hill with a gentle curve for a distance of 35 feet, when it narrows to a width of 2 feet, and 4 feet high. Passing through this narrow door the cave immediately enlarges to a width of 6 feet, and 10 feet high; then, taking a sudden bend, passes out westward on a rocky shelf on the top of a precipitous rock. The distance from the east entrance to where it passes out in the west is 51 feet, and varies in height from 10 to 4 feet. These observations apply to the cave when excavated. When we had progressed with the exploration a few feet inside the cave, on examining the strata, I found it was composed of five distinct layers. The method I adopted in removing the stuff was—first, to remove the top layer for a distance of 3 feet (horizontally), and so on, layer after layer, to the bottom, putting in a separate place any object of interest which I found in each or any of the layers. I examined each stratum separately as it was carried out in buckets, turning it over with a trowel so carefully that the smallest object could not escape my notice.

The upper layer was entirely composed of small angular limestones, somewhat larger than road stones, in which there were no objects of any interest found. It covered the whole surface of the cave from the east to the west end, and had an average depth of from 1 foot in the east to 18 inches in the west end. I was greatly puzzled to know how these stones could be introduced, especially when I found them so uniformly deposited; but when I was exploring the west end of the cave I believe I was able to solve this problem, which I shall explain presently.

The next layer was composed of black mould, and had an average depth of 16 inches: it contained traces of charcoal, some human and animal bones, quite dark in colour, produced by the dark earth in which they were embedded.

The third, or next stratum, consisted of a peculiar kind of brown compact earth, containing some angular blocks of limestone, which bore marks of fire; these stones must have been carried in by the cave dwellers, as no stones fell from the roof in this end of the cave, as it formed an irregular pointed arch, the surface presenting a smooth appearance, the result of water at the time it traversed the cave. There were also found in it a great many fragments of rude pottery, which had a dark smoked appearance, which it is evident were portions of a cooking vessel; they corresponded exactly with some fragments I have found in crannoges; there were no marks of any kind on these pieces of pottery indicating ornamentation. On the same floor there were human and animal remains found scattered far apart; and in no instance during the whole exploration of this end of the cave did I find human remains huddled together.

The fourth layer was composed of yellow clay traversed by veins of brown earth, and yielded traces of charcoal all through, together with human and animal remains.

The next and lowest stratum rested on the solid rocky floor of the cave, and to my mind is the most important of the series, as it bears evidence showing the extraordinary changes which the surrounding country has undergone since its deposition. In depth it varied from 1½ to 2 ft., and consisted of gravel with a covering of sandy clay of a yellow colour about 3 or 4 inches deep. I found no human or animal remains in the gravel, but imbedded in the sandy clay on its surface I picked up two rude flint implements of Palæolithic type; one of them (fig. 3) was

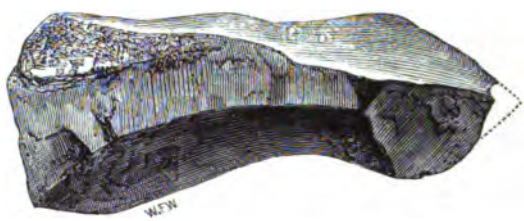


Fig. 3.

of a jet black colour, the other (fig. 4) a dusky brown, and measuring about 3 inches each. I submitted the black flint to the Rev. Dr.

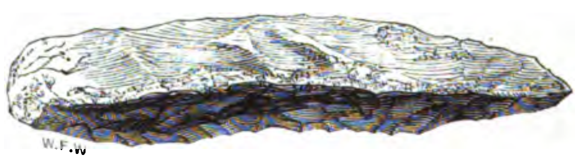


Fig. 4.

Haughton, who pronounced it Lydian stone. None of the material from which the flint flakes were manufactured is found in Fermanagh. I also found in the same bed of yellow clay human remains, including several portions of a skull, the hollow sides of which were filled with the material comprizing the layer. After I brought these portions of skull out of the cave I picked out the clay, which was firmly packed in their hollow sides, and found it identical with the stratum from which they were taken. My object in going so minutely into detail is to show that these portions of skull could not possibly have fallen during the process of exploration from a higher stratum. There were also some animal remains mingled with charcoal found in the same layer.

Having thoroughly explored this end of the cave up to the narrow part which intervenes between the east and west end, and finding it very inconvenient to advance any further with the excavation from this side, I determined to try the other end. Up to this point there were 35 feet excavated, leaving 16 feet still unexplored. I directed the men to pass round a steep rocky declivity to the west entrance, which opens out on a shelf on the top of a precipitous rock, and was hid from view by briar and stunted blackthorn bushes—after the removal of which we found the entrance almost closed with *debris* measuring only 1½ feet high, by 2 feet broad. This end presented the same denuded appearance as the other. The cave ran nearly parallel with the escarpment, and would have been entirely obliterated only for the hardness of the rock in which it is, which appears as a bulge on the face of the cliff, and is merely a fragment of a much larger cavern.

Finding that the cave formerly extended on this side to the very edge of the cliff, 7 feet from the present entrance, I had all the *debris* and stones removed which covered this space, and found, as I anticipated, the old cave floor. In this earth and *debris* I found traces of charcoal. After removing this pile, which had accumulated before the entrance, and having now exposed a good vertical section of the mass of earth which filled this end of the cave, we removed each layer separately, as was done at the other end; the first was composed of small stones, being a continuation of the same stratum from the other end, but 6 inches deeper, being 18 inches thick. Being anxious to know how so large a quantity of stones could be conveyed in and deposited so uniformly over the surface, I made a careful inspection of the rocky surface round the entrance. In passing up a steep rugged surface of rock which ascended from the entrance, I found that owing to atmospheric agencies small stones became detached and rolled down its surface, falling over the cliff below, and forms the greater portion of the *talus* abutting its base. When the cave extended to the edge of the cliff these stones could not possibly fall into it; but when it became "weathered," and the roof tumbled in, forming a pile before the present entrance, almost as high as the roof of the cave, which caused the entrance there to be vertical for a few feet, and had the external appearance of a "pot-hole;" right above this aperture there was a shallow trough which ran up the face of the mass of rock from which the small stones were detached, causing a great many of them in their course down from the higher slopes to roll into the mouth of the cave. Then rains and melting snows, owing to this descending hollow, converged towards the entrance, and there being a considerable incline from this to the east end of the cave, formed a current of water with force enough to carry the stones over the surface from the west to the east end of the cave.

The above facts lead me to infer that the cave when occupied by man, and even up till the time the urn was deposited in the top stratum, on which these stones rested, that it extended (as I have already said) to the edge of the cliff, as none of these small stones were found in any part of the cave except the surface. Therefore, I conclude that 7 feet of the rocky strata composing this end of the cave has worn away since the urn was deposited, in which were the last human remains introduced into the cave. The next or second layer was composed of dark unctuous mould three feet thick. During the course of its removal we did not find any remains except charcoal till we had penetrated to a distance of 9 feet from the entrance; at this point there appeared a recess or niche in the side of the cave. One of the men working here struck a large stone with the pick; after it was removed, and clearing away the clay where it rested, the large cinerary urn was discovered, and unfortunately fractured. It (fig. 5) was inverted on

Fig. 5.

a flag, and covered burnt human remains. The urn was packed in the recess in the rock with dry mould, and protected on the side next the cave with the large flag, which measured 2 feet 4 inches long, and 20 inches broad. There were fragments of a much smaller vessel found near this niche, which appeared to be rudely ornamented (fig. 6), but

Fig. 6.

no traces of human remains were found in connexion with it, although I carefully examined the spot; probably it was placed beside the remains of the departed as a food vessel.

The burnt bones found in the urn must have been subjected to powerful heat, as their contorted appearance indicated. They represented a male and female, as may be seen by the appended report.

There were no other remains, or any objects of interest, found in this layer.

The next stratum was about 2 feet deep, and consisted of pale brown and rather compact earth, including some limestone blocks, which had evidently fallen from the roof, as its appearance indicated. During the removal of this layer there was nothing of interest found except small pieces of charcoal, which I observed under some of the stones as they were being removed.

The last layer was now uncovered, which corresponded exactly with the lowest stratum at the other end, being composed of yellow sandy clay and gravel; nothing of any importance was found in it except the remains of an ancient hearth, consisting of ashes and charcoal, which was partly covered with patches of stalagmite. This was found at the very lowest and most commodious part of the cave bottom. being 10 feet high when excavated, and 5 feet broad. A large stone, about 6 cwt., rested with its larger end on the surface of the hearth, the other and smaller end leaning against the side of the cave. I measured all its surfaces, and found that it had fallen from the roof, as it corresponded in every way with a cavity directly above it, and if it could have been raised up to the roof in the position in which it lay, it would have fitted into the cavity. The reason I describe this stone so minutely is to show that it was not placed designedly there.

The smaller end formed part of the base on which the flag which supported the urn rested; I infer from this that at the time the urn was deposited there was at least 6 feet deep of earth in this end of the cave. From the hearth to the spot where the urn was found there is a vertical space measuring 5 feet, and from the urn to the surface 3 feet, making a total of 8 feet of cave earth, including the small stones on its surface, all of which it is quite evident accumulated very slowly. A long interval of time must have elapsed since the early dwellers occupied the hearth till the time the urn was placed in the upper layer of cave earth.

Dr. Joyce says ("Irish Names of Places"): "In early ages it was usual to burn the body and place the ashes in an urn, which was deposited in the grave. It seems very extraordinary [he continues] that all memory of this custom should be lost to both history and tradition, for I am not aware that there is any mention of the burning of bodies in any, even the oldest, of our native writings."

According to Dr. Joyce, the people who practised this custom in this country must have been very ancient; but according to the chronology of the cave, they are comparatively modern. In ancient Greece and Rome, burning the dead gained ascendancy over other modes of burial as civilization advanced; and, strange to say, as Europe is attaining

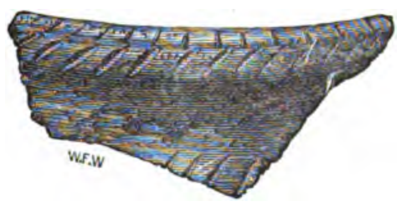
Fig. 7.

a higher level of culture and civilization, this sentiment is evolved, and appliances invented to carry out this *advanced* (!) mode of burial.

The large urn (fig. 7) was rudely but very strongly formed, and composed of coarse material: brick, earth, and angular pebbles of small size seemed to be what it was composed of. It stood 14½ inches high, 15 in diameter, and 3 feet 11 inches round the neck; the rim was 1½

inches broad, and bottom 2 inches thick: the latter was measured after it was fractured.

It was almost devoid of ornamentation, except a few lines that may have been scratched across the rim when the clay was soft.



The lines slanted upwards, like the fibres of a leaf, to right and left, and closely resembled some of the scratched lines on the terra cotta wheels figured in Dr. Schleiman's book on ancient Troy, which he regarded as symbols of the chariot of the sun.

Professor Macalister—who assisted the Rev. Dr. Haughton in inspecting the human remains found in Knockninny cave, together with a large quantity of animal bones and some human remains, which I found in caves west of Enniskillen—was of opinion, from the small proportion of animal remains found at Knockninny, compared with what I discovered in the Knockmore caves, that the human remains found in Knockninny, in the strata below where the urn was found, were introduced for the purpose of sepulture.

There was not a single feature connected with the strata or the remains found therein to indicate burial. The Knockmore caves were nearly in every respect different to Knockninny. They passed into the rocky mass with a considerable dip, and when the waters which traversed them became intermittent, angular stones of various sizes choked up some of the narrower parts of the caves, causing a quantity of rock *debris* and gravel to accumulate in the cave, while the water still percolated through; and the principal portion of all the animal remains which I found, including horse, wild boar, wolf, deer and dog, together with many other species, were washed into the caves;

and while the water percolated through the cave, the animal bones were caught in the rock *debris*. This I have evidence to prove beyond doubt, although these caves at the present time stand high above the level of any current of water in the locality.

Knockninny cave was quite different; it was horizontal, and (as I have said before) only a fragment of a cave which passed through a bulge in the face of the escarpment from east to west, a distance of only 51 feet, and open at both ends: and after the water which originally ran through it found a lower level it became dry, and no doubt was sought as a place of shelter and refuge by nomadic tribes.

Through the whole strata of the cave the remains were found apart; even portions of the same skull were found in different parts of the cave, but always in the same stratum. These facts would support the theory that cannibals occupied the cave from time to time, or during the course of ages solitary individuals, who sought it as a shelter and occasionally died there. Their bodies becoming decomposed, their bones became scattered over the surface of the floor by animals which it is quite evident inhabited it; and each successive floor of the cave, as it was slowly formed, furnished its own quota of animal and human remains. The presence of charcoal in each layer of cave earth would corroborate the hypothesis that it has at various intervals been used as a habitation.

I might observe, before I pass on to explain the nature of the lower stratum of the cave, that there is hardly any branch of the human race but who at one period of their history were cave-dwellers, from the savages found in various parts of the world at the present time back through a long past, even before that ancient institution was established, the Chinese Empire. "The Chinese," says Tylor ("Primitive Culture"), "can show with all due gravity the records of their ancient dynasties, and tell us how in old times their ancestors dwelt in caves, and ate raw flesh till, under such and such rulers, they were taught to build huts and prepare skins for garments."

Then if we turn to the Homeric Cyclops:—

> "Housed in the hills they neither buy nor sell,
> No kindly offices demand or show,
> Each in the hollow cave where he doth dwell
> Gives law to wife and children as he thinketh well."

In a late volume by H. H. Bancroft on "The Wild Tribes of the Pacific States of North America," we read that a great many of these tribes are cave-dwellers, and "love the inhospitable mountain and their miserable burrowing-places better than all the comforts of civilization."

I need not go into prehistoric times, as the caves found in all countries bear witness to the same fact. I will now wind up this paper with some observations on the lower stratum of the cave, in connexion with the denudation of the surrounding country.

This stratum (I have already stated) is composed of gravel with a coating of yellow sandy clay, both of which, it is quite clear, were carried in and deposited by water. On a careful examination of this material, I was rather surprised to find that a large proportion of this old silt and gravel was foreign, not only to the formation which the cave penetrated, but even to the hill. Here in a cave near the top of this isolated hill, I find the *debris* of a gritty sandstone, not found in the locality except in a mountain ridge on the other side of the valley nearly a mile distant, the cave having an elevation of 330 feet above the valley bounding it on the one side, and 349 feet above Lough Erne, which bounded it on the other. From whence did it come? This was the question I had to answer. In order to solve this difficult problem, I commenced to investigate the physical phenomena connected with the geology of the district, with which I was slightly familiar before, but now felt that a closer inspection was necessary and important, as I had found imbedded in this lower stratum containing the foreign matter, the two wrought flints and portions of a human skull described above.

I shall describe the outlines of the country west of Knockninny, and give a detailed account of facts I discovered, which clearly show the extraordinary amount of denudation which has taken place in this locality.

Knockninny skirts a group of mountain ridges which lie on its south-west side, and cover an area of about 15 square miles. This area is represented on Jukes' map as a patch of coal-measures. The slopes of one of these mountain-ridges rise from the other side of the valley adjoining Knockninny, and terminate at an altitude of 1100 feet above the sea level. The valley intervening between the base of this mountain and Knockninny is about three-quarters of a mile broad. Cuilca mountain raises its lofty crest further west, and at a distance of 5 miles from Knockninny, and is the highest of the group, and has an altitude of 2188 feet above the sea. Standing on its summit you may see a group of hills, to which I have referred above. The ridges or hills (for they are of various shapes) lying next Cuilca approach nearest to it in altitude; and the hills forming the borders of the group have a much lower altitude, especially those on the north-east side, which pass from Cuilca with a gradation down to the valley of Lough Erne.

Cuilca is a ridge about 2½ miles long, and is entirely composed of sandstone; but in the slopes below its base the carboniferous limestone crops out and is continuous round through the valleys and the base of the mountains immediately surrounding. The hills also which form the outskirts of this area (already referred to) with a similar altitude to the valleys around Cuilca, are entirely composed of limestone, with the exception of a thin patch of sandstone along their tops. Cuilca being the backbone of the district divides the drainage system of the country, and from its base there radiates in various directions a series of valleys with a considerable incline for several miles, which broaden from one to five miles as they extend. Through one of these valleys the infant Shannon meanders southwards, and issues out of a cavern at the base of Cuilca known as the "Shannon pot."

I have traversed all these mountains and examined their strata, escarpments, and intervening valleys. (The latter reveal the limestone surface). On the face of some of these escarpments thin seams of coal crop out, and in the escarpment in the opposite side of the valley there are corresponding seams, and similar strata as found on the other side, and on both sides horizontal. Some of these valleys have been scooped out to a depth of 1600 feet. Notwithstanding the presence of these deep valleys, all the geological phenomena found in the locality bear evidence in favour of the hypothesis that all these mountain ridges which rest on a portion of the great limestone plain which covers the centre of Ireland, and are principally composed of sandstone, at one period formed one continuous undulating plateau covering the limestone formation in this part of the country; but the greater portion of it has been removed by denuding forces, leaving these ridges behind—presenting now the appearance of streaks and patches of snow, which sometimes remain on higher summits after a thaw, when the sheet which covered the country has passed away.

The rain water which courses down the sides of these mountain ridges converges into little rivers which traverse the surface until they reach the limestone formation at a lower level, when they generally penetrate its strata, and form subterranean passages which often result in deep ravines. I have examined a great many of these "swallow holes" which form the entrance to these underground water ducts, and found rounded sandstones amongst the *debris* in their bottoms, of considerable size, which were transported hither by the current from higher levels, where the sandstone thins out on the surface of the limestone. This description of the geological features of the locality, confused as it is, may help us to understand more about the denudation of the sandstone formation, which was continuous from this locality over Knockninny hill before it became detached by denuding forces from the main formation in the locality.

Standing on the east shoulder of Cuilca you observe a valley which passes from its base (to which I have already referred) eastward, and broadens and deepens as it extends, and passes at almost right angles through the mountain ridge which bounds the valley on the southwest side of Knockninny, then broadens into the valley of Lough Erne and encompasses Knockninny at its extremities; and supposing a current of water filled this valley from the base of Cuilca down to Lough Erne, a distance of five miles, Knockninny, which is situated at its lower end, would appear an island, and before the valley which surrounds it was sculptured out by subaerial agents, the waters which passed down the slopes of Cuilca passed over the top of Knockninny into Lough Erne.

The evidence supporting this hypothesis I have found on the surface of Knockninny, which I shall now adduce. Along the top of the hill there are several large "swallow holes" corresponding in every feature almost with those I have examined in the valleys surrounding Cuilca, with this exception, that no water passes through them. I went down into these holes, and after removing the rubbish and *debris* on the surface, I found in every one of them rounded sandstones of various sizes mingled with limestones. I also saw similar stones here and there in the ditches which form the fences on the hill, which were gathered off the surrounding surface. Now the nearest sandstone strata in the locality are in the mountain ridge rising in the south-west side of the valley adjoining the hill, and the intervening valley is 400 feet lower than the top of Knockninny, where the "swallow holes" are. All these phenomena to my mind clearly show that Knockninny gradually rose like a huge boss or outlier, as the surrounding and softer strata were being worn away by denudation. I have examined its slopes, from its east and west shoulders to its base, and found beds of gravel at intervals down the whole way, which I regard as the *debris* left behind when nature's sculpture was forming the hill. One of these beds occurs 26 feet below the mouth of the cave, and is exactly the same as is found in the bottom of the cave underneath the sandy clay. I examined an escarpment in the ridge opposite, intervening between Cuilca and Knockninny. Through it the valley passes on its way from the base of Cuilca to the lake; in the centre of the valley Knockninny rises, and I found at an elevation of about 700 feet above the valley, gritty sandstone, the *debris* of which I found in the rivulets which traversed its surface, and it corresponded with what I found in the cave, mingled with limestone gravel. All these facts point to extraordinary changes of the surface of the country which surrounds Knockninny.

Since the water which formerly passed through the cave retreated to a lower level, leaving the floor dry and covered with this deposit, the adjoining strata have been removed to a depth of 330 feet below the entrance of the cave. A question here suggests itself—did man inhabit the cave immediately after it became dry, or not until the surface of the country had assumed its present outlines? The evidence found in the cave is in favour of the former hypothesis, as there was not a single particle of cave earth associated with the flint implements or human remains found in the lower stratum. And it is hardly probable that, during the long period which must have elapsed from the time the cave became dry, and formed a refuge or dwelling for savage tribes, till the time the valley assumed its present appearance, no cave earth would be deposited.

Suppose we assume that the cave was not occupied until the surrounding surface of the country presented its present configuration, then we are bound to believe that the cave earth must have accumulated very slowly, so much so that an inch would not be formed while 330 feet of rocky strata were washed away. And if we take Croll and Geikie's calculations as to the rate at which valleys are scooped out (which is extremely slow), although they state that they have discovered the "unexpected rapidity" with which the surface is wasted by denudation, this "rapidity" amounts to 1 foot in 1500 years. Denudation varies exceedingly, and there is evidence in this locality that the denuding forces were much more powerful formerly than at present.

No matter from what side we view the evidence furnished by the cave deposits and its environs, we must, I presume, be convinced that the tribes whose relics I found in the lower stratum are of enormous antiquity.

By going into detail so much I may have extended this paper to a weary length, but I thought it better to leave all the facts connected with the exploration, together with a description of the physical features of the surrounding country, before the Members of the Academy, and let them form their own conclusions.

At the request of the Rev. Dr. Haughton, I forwarded the large cinerary urn to the Museum of the Academy, also its contents, together with the fragments of pottery found in the cave.

I am deeply indebted to the Rev. Dr. Haughton and Professor Macalister for the appended Report on the human remains found in the cave.

Report on the Bones found in the Knockninny Cave.

1st. *Human Remains.*

A.—Deepest Series. Bones of an adult man of unusually large size, including—

1. Right parietal, large fragment.
2. Squama occipitis, ,,
3. Right temporal, complete.
4. Left parietal, several fragments.
5. Left squama temporis, fragment.
6. Portion of frontal, glabellar region.
7. Lower lateral incisor tooth.
8. Lower left bicuspid tooth.
9. Upper left third molar tooth.
10. Lower left third molar tooth.
11. Third rib.
12. Piece of lower true rib.
13. Right malar.
14. Left ulna, fragment.
15. Right second metacarpal bone.
16. Right ischium, fragment.
17. Left tibia, ,,
18. Right femur, ,,
19. First phalanx of right hallux.

B.—Second Series. Bone of adult, moderate size.

1. Left temporal, nearly complete, petrous and mastoid; of much smaller size than A 3.

C.—Third Series. Bones of a child, aged about 10–13.

1. Right ilium, crest and acetabular epiphysis absent.
2. Left ilium, „ „ „ „
3. Portion of squama occipitis.
4. Right scapula; body, wanting all epiphyses.
5. Left scapula, „ „ „
6. Epiphysis of tibia.
7. Left maxilla, with undeveloped last molar teeth.

The jaw appears more advanced than the other bones, and may have belonged to a second child.

D.—Fourth Series. Remains of three adults.

a 1. Lower first molar tooth, left.
a 2. Lower first molar tooth, right,
a 3. Left ilium, fragment.
a 4. Left humerus, lower end.
a 5. Right third (?) metatarsal.
a 6. Right tibia.
a 7. Right fourth metatarsal.
a 8. Right radius, fragment.
a 9. Right ulna, „
a 10. Left radius, „
a 11. Left ulna, „
a 12. Right scapula, „
a 13. Left femur, „

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b 1. Left humerus, lower end.
b 2. Fragment of right humerus.

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c 1. Right humerus, enormously large.

These differ in size from *a* 4. Both sets, *a* and *b*, are much darker in colour than Series A, B, and C; *c* is much larger than *a* 4, or *b* 1 or 2.

E.—Bones found in the urn, burnt.

a 1. Left frontal, with remains of persistent frontal suture, and moderate sinuses. (Fig. 10.)
b 2. Left frontal, with smaller sinus, and much feebler external angular process. (Fig. 11.)

a 3. Fragment of left frontal, agreeing with No. 1.
a 4. Fragments of right frontal, three pieces.
a 5. Fragments of left parietal, six pieces.
6. Fragments of squamosal right (?).
7. Fragment of left petrous bone.
b 8. Fragment of right petrous and mastoid.
a 9. Squama occipitis, left side, two fragments.
b 10. Squama occipitis, left and middle, does not fit No. 9.
11. Left malar.
12. Right malar.
13. Left ascending ramus of mandible, *small* adult.
14. Right femur, four fragments.
15. Left femur, fragment of condyles.
16. Lower end of right fibula.
17. Right tibia, fragment of shaft.
18. Left tibia, back of inner condyle.
19. Crest of ilium, right.
20. Left femur, back of popliteal ridge of.
21. Right humerus, upper end, two fragments.
22. Left humerus, lower end.
23. Right radius, middle of shaft, two fragments.
24. Fragments of ribs and scales of long bones.

From Nos. 1, 2–9, and 10, it is obvious that the remains of two individuals were in the urn—one a well-marked male, the other smaller, probably a female.

The individuals whose remains are found in the cave are thus at least eight—possibly nine—viz.:—

A Large adult man.
B Moderate adult man (?).
C Child (one, or possibly two).
D *a*, D *b*, two moderately large adults.
D *c*. Very large adult man.
E *a*. Male.
E *b*. Female (?).

It is *possible*, anatomically, that D *c* may belong to A, and B to either D *a*, or D *b*, if the geological evidence does not forbid such a fusion. The absence of all trace of upper extremities in A and B would seem to indicate such a relationship. This would reduce the minimum number of individuals to seven.

2nd. Animal Bones found in Knockninny Cave.

1. Canis lupus, very large jaws and femora, &c.
2. Canis familiaris.

3. Canis vulpes, one jaw, and several teeth.
4. Capra hircus.
5. Ovis aries (?).
6. Sus scrofa, some large tusks.
7. Bos taurus, one rib notched.
8. Lepus variabilis.
9. Lepus cuniculus.
10. Sturnus vulgaris, skull.

The smaller number of animal bones in proportion to the human (hardly two of the former for each one of the latter) is so different from the proportion found in the Knockmore caves, that it suggests a different method of the introduction of the human remains.

Fig. 10.

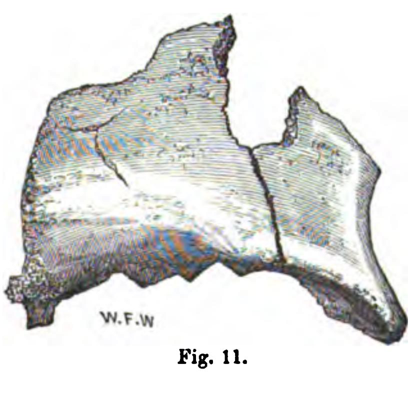

Fig. 11.

XLIV.—On Personal Errors in Astronomical Transit Observations. By John L. E. Dreyer, M.A., F.R.A.S., Astronomer at the Earl of Rosse's Observatory.

[Read February 14th, 1876.]

The numerous observations which during this century have been made at the astronomical observatories, have made astronomers discover a cause of errors in the observations, which contributes to diminish the accuracy which might otherwise be expected from our excellent instruments. It is the "personal error." And this error exists oftener in transit observations than in any other, for which reason it becomes of great importance in determinations of longitude, and in every comparison of the results of the determination of different observers as to the meridian passage of a star.

While working at the Copenhagen Observatory, my attention was, two years ago, turned to the study of this special subject, by the prize question of the University, for the answer to which I received the Gold Medal. When I, later, as astronomer at the Earl of Rosse's Observatory, had been examining several catalogues of nebulae, and even in these found the influence of the observers' individuality, I was induced to extend my researches on the subject. Added to this, I have been encouraged by several men of science, in whose opinion I could not but place the highest confidence, who thought it would be of some use to astronomers, if I published at once all the results of my studies of the literature, and my examination of all observations, which might contribute to the explanation of the phenomenon. In the paper I have the honour to lay before the Royal Irish Academy, will be found many facts generally known, but I have thought it advisable to treat the subject in its whole extension, in this way giving to astronomers a complete account of all the results which can be derived at present, with respect to personal equations.

Transits are now-a-days observed in two different ways, by the eye-and-ear method, and by means of the chronograph, of which the former method has been used since Bradley's time. Using this method, the observer counts the seconds of the clock, and compares the distance of the star from a vertical wire in the field of the telescope, at the last second-beat before the transit over the wire, with its distance at the first beat after the transit. In this way the observer judges what fraction of a second has passed between the first second and the transit.* In the chronographic method, the beats of the clock, by means of an electric current, make marks on a strip of paper, which is

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* Sometimes, but rarely, observers use another method, directly estimating the interval between the second-beat and the transit (see, for instance, Briefwechsel zwischen Gauss und Schumacher, i., p. 368).

folded round a slowly revolving cylinder, while the observer himself, in the moment he sees the star bisected by the wire, establishes (or in some apparatuses, interrupts) a current with a key, and in this way makes a mark on the paper, between two second-marks. He can then, afterwards, measure the distance between these marks, and determine the fraction of the second with great exactitude. In both methods of observing, it has been found that there exists a difference between the moments of culmination of a star, as found by different observers, using the same instrument.

It is to Bessel that we owe the discovery of this personal difference. He was not, however, the first who remarked a different estimation of transits, but his researches on this subject were occasioned by his finding in the Greenwich observations from 1795, that one of Maskelyne's assistants, Mr. Kinnebrook, had got into the habit of observing transits over the wires of the transit instrument $0^s{\cdot}5$ to $0^s{\cdot}8$ later than Maskelyne himself. In 1794 and the beginning of 1795, the observations of the two astronomers had agreed; but in August, 1795, Kinnebrook began to observe half a second later, which difference, in 1796, rose to $0^s{\cdot}8$. As it was Maskelyne's opinion that his assistant did not use the above mentioned way of observing by eye and ear, but some other irregular method of his own, he dismissed this, in other respects, skilful man. The matter was looked upon in this way by everybody; no one thought that there had been found a physiological phenomenon, which was perfectly independent of the observer's will.*

Bessel examined the matter again, and showed by his excellent investigations, which in 1823 were published in the eighth section of the Königsberg Observations, that most observers have a different way of estimating transits. He studied the equations between himself, Walbeck, and Argelander, and communicated the results *in extenso*, together with researches on the variations of the equations from time to time, the influence of the magnifying power, and other circumstances. With his usual acuteness, he gives, besides, several hints respecting the origin of the phenomenon. The remarkable result of Bessel's investigations was, that he himself observed about a whole second *earlier* than the two other astronomers. He found:—

In 1820, Bessel − Walbeck $= -1^s{\cdot}04$.
In 1823, Bessel − Argelander $= -1{\cdot}22$.†

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* Compare the history of the Greenwich Observatory in vol. ii. of Lindenau's and Bohnenberger's "Zeitschrift für Astronomie" (1816).

† Everywhere in this paper a difference $A - B = \pm \frac{n^s}{10}$ is to be understood in this way, that A observes $\frac{n^s}{10} \left\{ \begin{matrix} \text{later} \\ \text{earlier} \end{matrix} \right\}$ than B.

In the different equations which, in the course of years, were found between Bessel and W. Struve, there was a regular variation:

1814·8.	B. – S. =	– $0^s·04$.
1820·9.	,,	– 0·68.
1821·1.	,,	– 0·80.
1823·5.	,,	– 1·02.
1834·5.	,,	– 0·77.*

The two comparisons from 1821 and 1823 are indirect, derived from the differences, Struve – Walbeck and Struve – Argelander, found in Dorpat by direct comparison. The variation is very striking, and this circumstance, as well as the considerable amount of the personal equations, whose reality now was beyond doubt, showed the necessity of examining this remarkable source of error in all its details. It is, however, very seldom that personal differences are as large as between Maskelyne and Kinnebrook, or between Bessel and his assistants. The accordance between the different equations found in Königsberg, with respect to quantity and sign, makes it most probable that Bessel observed about a second earlier than most astronomers do; and he would probably have agreed tolerably well with Maskelyne, as the difference B. – Kinnebrook, in the opposite case, would have amounted to nearly 2^s.

As soon as the existence of the personal equations had been acknowledged in the scientific world, other astronomers began to make researches in this direction. First of all observatories, that in Altona, directed by Schumacher, imitated those in Königsberg and Dorpat, and the following remarkable differences were found there in 1833:—

Nehus – Wolfers = + $0^s·73$.
Petersen – Mädler = + $0^s·52$.†

These observations were made during a determination of longitude by transport of chronometers, and since that time very few determinations of longitude have been undertaken, without the observers having compared their method of observing, as the whole amount of the personal equations otherwise would make a part of the result. The investigations of personality in observing transits, which have been made on the occasion of determinations of longitudes, are very important, and have produced many of the most reliable results we have derived on this special subject. Besides, the plan for the observations adopted in several observatories has rendered constant determinations of the personal faults of the observers necessary; and this has especially been the case in Greenwich, where all the instruments are used alternately by several observers. From the year 1838, the volumes of the Greenwich Observations contain interesting discussions on the equations between the different observers, which we shall often have occasion to quote in the following pages.

* Königsberger Beobachtungen, viii., pp. 5, 6; ibid. xx. p. 31.
† Astronomische Nachrichten, xiii., No. 308; xlix., No. 1154.

I.

Before entering on the examination of the different results which can be extracted from modern researches, we shall shortly consider the methods by which the personal difference between two observers, and the absolute personal error of a single observer, may be found.

The most convenient, as well as the simplest way, to find the equation between two persons is to let the one observe the transits of stars over the one half of the wires in the telescope, and the other person observe the transits over the remaining wires. The single transits, reduced to the middle wire, give immediately the equation. By changing the half of the system of wires observed by each person, the influence of faults in the distances of the wires is eliminated. A change of this method is the use of a binocular eye-piece, which, by a prism, divides the rays coming from the object-glass into two parts, so that two observers at the same time may observe the transit of a star across all the wires. This method has for some time been used in Greenwich, but it causes often a change in the personal error to arise from the position of the observer, east or west; therefore, it cannot be recommended.* It is also in another way possible to use all the wires, by letting the two persons observe the projected image of the sun on a piece of white paper.† But as the observation of the luminous edge of the sun is very different from that of a star, a personal difference in the former need not be identical with that in the latter, so that a control by star-observations, at all events, is necessary.

Besides these methods—of which the first one is the simplest and the one most commonly used—several other methods of finding personal differences may be used. When Bessel, for instance, compared himself with Walbeck, each of them observed five stars a day, and every second day the same. By comparing the observations made on two consecutive days, two values of the clock-rate were obtained, the difference of which was equal to the double personal equation.‡ The equation B. – Argelander was, at the same time, found in another manner. Bessel had, in 1821, six times observed seven stars (used by Bradley and Maskelyne for determining the collimation error of the Greenwich quadrant); Argelander observed twice the same stars in 1823, while Bessel found the clock-error. A. found now the right ascensions to be larger than B. had done: the equation B. – A. was, therefore, on an average = – $1^{s}{\cdot}22$. A similar method is used in Greenwich, where the different observers at the transit instrument, from a series of stars, determine the clock-error separately, and reduce

* We shall afterwards come back to this peculiar case.

† About this method see Washington Observations, i. (for 1845), p. 49; Monthly Not., R. A. S., xix., p. 338; Monatsberichte der Berliner Academie, 1858, p. 615. We shall also later come back to the solar observations.

‡ Königsberger Beob., viii., p. 4. B. compared himself in 1832 with Busch and Argelander in the same way.—Ibid. xviii., p. 1.

their results by means of the clock-rate (found independently of personal errors) to a common epoch (0^h Sid. time). The differences between the resulting clock-errors for this epoch are then equal to the equations between the observers (with reverse sign, according to the mode of designation chosen in this paper).

During determinations of longitude, the personal equation between the observers has often been eliminated, by letting them exchange their stations, and begin observing again. The mean of the two resulting values for the difference of longitude is then the exact value, and half their difference is equal to the personal equation. This method supposes the personal error of both observers to be constant during the whole operation, but as this is not always the real case, it is the safest to determine the equation in one of the usual manners, best by letting the observers compare themselves with both instruments used at the two stations. Sometimes the equation has also been found by letting the two astronomers observe simultaneously at the same place, each using his own instrument; but as the uncertainty in the determination of the instrumental errors gets a considerable influence on the result, this method ought never to be used.

But the comparison between the habits of two observers does not give us any information about the absolute error of each of them, which it, of course, is of far greater interest to study; and it has, therefore, during the last twenty years, been attempted by several astronomers to construct an apparatus by which the personal error of an observer could be found. As we shall often, in the following pages, quote results obtained by such apparatuses, it will not be superfluous to give a short description of them, only entering a little into details respecting those with which important and trustworthy results have been obtained.*

Hartmann has described an apparatus in Grunert's "Archiv für Mathematik," XXXI., 1858 (also in the Astron. Nachrichten, LXV.), which only allows observations by eye and ear. A centrifugal pendulum turns in one second an axis on which a small disc, cut like an Archimedes-spiral, is fixed. At a certain phase of the rotation, an arm, which slides on the spiral, falls down and produces audible second-beats, while it, in the same moment, sets an escapement free, and causes a system of wheels, which before were at rest, to begin to move, and after having moved a certain part of a rotation—which, when the instrument is stopped, may be conveniently measured—causes an artificial star to pass behind the wire in a small telescope. While this goes on, the observer estimates the moment between two consecutive second-beats, in which the star (a steel pearl, on the circumference of a wheel, illuminated sideways) is bisected by the wire.

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* Prazmowski in Warsaw seems to have been the first one who has invented such an instrument, which was very much on the same principle as the modern "Time-collimators." As far as we know, no researches made with it have been published.—Cosmos, T. IV. (1854), p. 445.

A comparison between this estimated moment and the true distance of the transit from the preceding second-beat gives then the personal error. This instrument has only been used a little by the inventor himself, and it is too complicated.

Simpler, and therefore depending less on the exact manufacture of all the details, is the instrument used by MM. Plantamour and Hirsch, at the determinations of longitude in Switzerland.* Like the instruments of C. Wolf and Kaiser, it makes use of electricity; but in another way, in conjunction with the "chronoscope" for measuring very small intervals of time. This chronoscope is a fine clockwork with two hands, which turn once, respectively, in $0^{s}\cdot 1$ and in 10^{s}; as the dials are divided into 100 parts each, the one can show $0^{s}\cdot 001$, the other one, $0^{s}\cdot 1$. The axis of the former hand—which moves the axis of the latter by a toothed wheel—can be pushed backwards and forwards, by the establishing and interrupting of an electric current. In the former case, a cog-wheel on the axis is pressed against another wheel, which is moved by the clock and has 100 teeth, so that the two wheels will move together after less than $0^{s}\cdot 001$. When the current is closed again, the axis goes forward and the wheels separate; accordingly, the two hands are stopped. The passage of a luminous point behind a wire suspends the current, while the observer himself, in the moment he remarks the transit, closes it again. The hands of the chronoscope will, therefore, indicate the personal error of the observer, but, of course, only if it is negative; as the hands in the opposite case (when the observer closes the current before it has been opened) are not moved at all, so that it can only be seen that the observer has anticipated the transit, but not how much.† The artificial star is produced by a board, movable by a pendulum, with a small hole in it, through which the light of a gas-flame shines. Once during each oscillation, in the moment it passes the vertical line, the pendulum interrupts a metallic contact, and suspends the electric current, thereby letting the hands of the chronoscope join in the motion of the clockwork, until the observer, with a key, closes the current again, and stops the hands. The pendulum, board, and gas-flame were placed in the meridian-mark-room of the Observatory in Neufchâtel. An assistant has to move the pendulum towards the east; the observer lets it pass the vertical line towards the west, and presses the key when he sees the star go back again and (when the pendulum again is vertical) pass behind the movable wire in the transit instrument, which he, before the beginning of the observation, has made bisect the star. The metallic contact can be regulated by a micro-

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* Détermination Télégraphique de la Différence de Longitude entre les Observatoires de Genève et de Neufchâtel. Par E. Plantamour et A. Hirsch, Genève, 1864.

† This case happened several times during Plantamour's observations. Before calculating the probable value for the personal error, he, therefore, left out an equal number of the largest negative errors.

meter-screw, so that it is interrupted exactly in the moment when the pendulum is vertical, and the star in reality behind the wire.

The simple construction of this instrument guarantees the non-existence of constant errors in the results obtained by it.* But it is a fault in it, that a very considerable time is necessary for taking any great number of observations, as it has to be stopped, read off, and set going again after every single wire-transit.

A more suitable apparatus was invented by M. C. Wolf, of the Paris Observatory, who has described it, as well as a great number of observations and special researches on the personal errors and their origin, in the "Annales de l'Observatoire de Paris," Mémoires, T. VIII.† The artificial star is produced by a small opening in a board (illuminated from behind), whose image, by a system of lenses, is thrown on the plane of five wires in a small telescope. The board is at one end of an arm, which by a clockwork can be made turn round its centre. In this centre of the rotation is a lens of very short focal length; the image of the star produced by this lens is seen through another lens placed before the object-glass of the telescope. The image of the star, seen by the observer in the plane of the wires, is in this way made to move very slowly, so that the board moves 16 centimeters, while the image of the star only goes from the first to the fifth wire or 12 millimetres. The transits are observed by eye and ear, while the small "carriage" at the end of the arm, underneath the board, is furnished with a contact apparatus which automatically registers the transits on a strip of paper on which, also, the second-beats of the clock are marked. This apparatus consists of a steel spring (fixed on the carriage) with a very small ball or knot at the end, which is dragged along the surface of a wooden board, in which, at equal distances, five thin copper strips are inlaid. The latter must, before the beginning of the observations, be adjusted by fine micrometer screws, so that the star will be behind a wire in the telescope when the contact of the small ball with any of the copper strips closes an electric current, or, during a retrograde motion of the star, opens it. In either case the absolute moment of the transit will, therefore, be registered on the same paper on which (by another current) the seconds are marked, so that a comparison of the marks on this paper with the moments of transits estimated by the observer, gives the value of the personal error.

The observation is made in the following way:—The apparatus is adjusted, and the observer sets the clockwork going. The contact apparatus and the star will, however, stand still till a small weight is put on a plate. This causes the transit to take place. When it is over, the weight is put on another plate, and the star will now go back

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* The very important researches for which this apparatus has been used are, however, independent of constant errors, as we shall see further on.

† Recherches sur l'équation personelle dans les observations de passage. Par M. C. Wolf.

again, and pass the wires a second time, this time registering its transits by the interruption of the current. By placing a prism before the eye-piece during this second transit, the motion of the star will, to the observer, seem to take place in the same direction as during the first one. By this arrangement of the observations, small imperfections in the contact apparatus (which would establish or interrupt the current a little before or after the right moment) will have no influence at all on the mean of two consecutive transits, and the bending of the spring will only cause an imperceptible fault in the same. Wolf's determinations of his personal error were always founded on 40 transits, 20 in each direction, and as the instrument was very carefully treated, and all sources of faults examined, his results deserve the highest confidence.

The instruments we hitherto have mentioned have not been generally used by astronomers, but only by their inventors and a few other persons. This is not the case with the different instruments successively constructed by the late Professor Kaiser, in Leyden, which are well known in the scientific world, especially the latest constructed, which has often been used in determinations of longitude on the Continent, as well as in Pulkowa, and which is generally termed a time-collimator. Kaiser has in the course of years constructed three apparatus. As early as in 1851, this eminent astronomer proposed to apply the principle of the nonius to determinations of time, and promised later to describe an instrument based on this principle, and suitable for finding absolute personal errors.* This promise he carried into effect in 1863 by publishing a paper which, besides the description of the apparatus, contains a great many observations taken with it.† The arm which carried the artificial star interrupted a current in the moment of the transit, which caused an electro-magnet to let its armature fall, whereby a pendulum, which hitherto had been kept in its greatest elongation from the vertical position, was set going. By the coincidences of this pendulum with the clock used for the observation, the true moment of the transit could be determined with great accuracy. Numerous experiments were made with this instrument by the astronomers in Leyden, and Kaiser introduced now the custom to let astronomical students practise with observations of artificial stars.

The two other instruments of Kaiser are in principle more like C. Wolf's apparatus, but may be used for chronographic as well as for eye-and-ear observations.‡ The first of them has several arms fixed on

* Tijdschrift voor de Wis- en Naturkundige Wetenschappen, xv., page 9.

† "De volledige bepaling van personlijke fouten bij sterrekundige waarnemingen," in the xv. vol., page 173, of the Verslagen en Mededelingen der K. Akademie van Wetenschappen, Afdeling Naturkunde (Amsterdam, 1863). As it was found that this paper was very little known on account of the language, the apparatus alone was again described in the Archives Néerlandaises des Sciences exactes et naturelles, vol. i., Hague, 1866.

‡ The first of them, as well as observations made with it, are described in the "Verslagen en Mededelingen e. c.," II. series, vol. ii., pp. 216 and foll. (1868):

a perpendicular axis, which by a simple small clockwork can be turned around itself. Each arm carries on the end a lamp which, by the help of a screen with a small hole in it, and a lens, can produce an artificial star, which, by the rotation of the axis, passes across a wire represented by a very thin strip of black paper pasted on a piece of oil paper, curved cylindrically, and opposite which a small telescope is placed. In the moment one of the stars is bisected by the strip of paper, an electric current is made. This is done by a copper fork, with two prongs fixed at the end of the arm, and at the same time touching two drops of quicksilver in which the conducting wires end. The forks may be moved a little by screws, and must be adjusted carefully, so that they establish the current exactly when the star is placed behind the wire.

The second instrument, which at present is most in use, is only a modification of the first one. It has only one arm, which by clockwork is drawn from one side of a mahogany board, in which one end of it (that at which the lamp is placed) is fixed. The velocity of the motion can be easily altered (as also in the former instrument). At the free end of the axis is a lens, which causes an image of a small hole in a screen before the lamp to fall on a piece of oil paper (curved as a cylinder) on which any number of dark perpendicular lines may be drawn. Within reach of the observer (as he stands before the telescope) is a string, by which he, when a transit is over, can bring the arm back to its original position (hereby winding up the clock again), so that a new transit may take place. The metallic contact is here, as in the former instrument, produced by a drop of quicksilver, but this is placed at the end of the arm, and accordingly moved along with it, while the thin brass wires which successively dip themselves into the drop are fixed on a brass arch, on the mahogany board. These wires are leaning heavily against small levers, which may be moved a very little around their centre by means of screws. In this way, each contact apparatus may be carefully adjusted. The instrument may be used for either kind of transit observations; the different electric currents may be arranged for the method of observing, by a commutator, without any loss of time.

A slight modification of this apparatus has, under the name of time-collimator, been much in use on the Continent, only having a strip of metal instead of the quicksilver drop.*

We have now given a short description of all the instruments for finding personal errors which have come into practical use.† It is

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"Ueber einen neuen Apparat zur absoluten Bestimmung von persönlichen Fehlern bei astron. Beobachtungen." Both instruments are shortly described in the Annals of the Observatory in Leyden, ii., 1870, pp. 19 and foll. (Beschreibung der Zeitcollimatoren der Sternwarte in Leiden).

* Bericht der Conferenz der Europäischen Gradmessung, Berlin, 1867. Annual Reports of the Pulkowa Observatory (Jahresberichte, e.c., 1869, page 8; 1870, page 5).

† Professor Harkness has suggested a very simple apparatus (Report on the

difficult to say whether these instruments answer their purpose perfectly. Each single one of them must of course be most carefully examined, in order that constant errors in its results may be detected, and their causes done away with. When this has been done (as in the case of C. Wolf's apparatus), there is no reason for not relying upon the exactness of the results obtained with it, within a reasonable degree. And several of these instruments have, by a careful construction of all the details, furnished us with results which agree extremely well. Kaiser, for instance, found, with his first instrument, the probable error in a single determination (that is, by a single wire transit) = ± 0ˢ·081, from the results of four observers,* while Wolf's apparatus gives the probable error of a double observation over one wire = ± 0ˢ·038.† The possibility of the existence of constant errors in the results is certainly not excluded by this, nor by another control which has been tried by comparing the results of artificial transits with those of real ones. We give the following examples here:—

Apparatus – stars =	0ˢ·035	Plantamour and Hirsch.
	0 ·02	Albrecht and Van Hennekeler.
	0 ·004	Albrecht and Valentiner.
	0 ·03	Tietjen and Valentiner.
	0 ·002	Bäcklund and Valentiner.

All these differences are within the degree of exactness possible to be attained, as we shall see presently. But artificial stars have not always agreed so well with the real ones as in the determinations of personal equations which we have just quoted. There appeared, for instance, during the determination of the difference of longitude between Leyden and Brussels, in 1868, a perfect discordance between the transit instruments and the time-collimator; but the observations with the former instrument differed just as much, *inter se*, and there can hardly be any doubt that a special cause of variation in the personal equations has influenced the observations.‡ The mistrust in his own apparatus which Kaiser, by this, was led to express,§ was therefore apparently unfounded, and the results furnished by time-collimators may be considered as very fairly representing the true errors of the observer.

After having considered the accuracy of artificial transits, it is natural to test the degree of exactness which may be attained in determinations of personal differences by means of simultaneous observa-

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difference of longitude between Washington and Havanna, 1870, page 13), but we do not know of any published observations taken with it. A proposal of Dr. E. Kayser's (Astron. Nachrichten, No. 1665) seems perfectly impracticable.

* Verslagen en Mededelingen, xv., 1863, page 207.

† Annales de l'Observatoire Impérial de Paris, t. viii., page 178.

‡ We shall further on consider this circumstance fully.

§ Annalen der Sternwarte in Leiden, ii., page 153.

tions with a transit instrument. The greater number of observations which may be consulted for this purpose allow us to enter more fully into this research.

When we want to find a general expression for the probable error of a personal equation, deduced from simultaneous observations of a single star across the two halves of the system of wires, we must take into account a circumstance which has been experienced in nearly every series of observations. We allude to the fact that a far greater uncertainty in the value of the equation is found by comparing the results of different stars with one another, than might be expected from the accordance between the transits of one star over the different wires. It must be supposed that a new cause of errors arises from the observer's passing from one star to another, or that the observer, in the intervals between the observations, gets out of practice, and each time has to form for himself a new habit of estimating the transits. C. A. F. Peters finds, for instance, as mean of five results, the probable error of a personal difference:*—

By comparing the single wires reduced to the middle wire.		By comparing the results of different stars with the mean of them.	
Eye & Ear.	Chronograph.	Eye & Ear.	Chronograph.
$\pm\,0^s{\cdot}071$.	$\pm\,0^s{\cdot}051$.	$\pm\,0^s{\cdot}141$.	$\pm\,0^s{\cdot}061$.

It has, besides, been remarked by experienced astronomers, that the transit over the first wire often does not agree as well as the others do, after having been reduced to the middle one, and it is, therefore, not improbable that zone observations, which sometimes only are made over one or two wires, may be affected by constant errors.†

For these reasons we cannot but approve of the expression for the probable error of a personal equation found by one star, which has been proposed by Dr. Albrecht:‡

$$W^2 = A^2 + E^2,$$

in which A is the probable error, found by comparing the transits over the single wires with one another, and E the error produced by the variation of the equation in going from one star to another. As we here only consider the most common method of finding a personal equation, we may suppose that each observer observes n wires, and

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* Astronomische Nachrichten, vol. xlix., page 27.

† See Argelander's remarks in "Vierteljahrsschrift der Astronomischen Gesellschaft," vii. (1872), page 16.

‡ Ueber die Bestimmung von Längendifferenzen mit Hülfe des Elektrischen Telegraphen, Leipzig, 1869, page 26.

that their probable errors of a transit over one wire are respectively a' and a''. We find then—

$$\Delta = \sqrt{\left(\frac{a'}{\sqrt{n}}\right)^2 + \left(\frac{a''}{\sqrt{n}}\right)^2} = \sqrt{\frac{a'^2 + a''^2}{n}}.$$

As the probable error in a single wire-transit, for experienced observers, generally amounts to nearly the same quantity, we may in the above formula introduce $a = \frac{1}{2}(a' + a'')$ instead of a' and a''. We have then—

$$\Delta = a\sqrt{\frac{2}{n}},$$

and accordingly (as there is no reason why E should be dependent on the number of wires)—

$$W^2 = \left(a\sqrt{\frac{2}{n}}\right)^2 + E^2.$$

W is here the probable error, which appears from the accordance between the results of different stars. From this we, therefore, find the probable uncertainty in a personal equation, arising from the observer's passing from one star to another—

$$E = \sqrt{W^2 - \frac{2}{n}a^2}.$$

If we, for instance, from the observations given in the Report on the determination of the difference of longitude between Berlin and Lund, compute the value of E, we may either deduce W from the deviations of the single values of the equation between the observers (Valentiner and Bäcklund) from the average value for one night, or we may put all the observations, made on different nights, together, and deduce W from their accordance with the mean of them all. In the former way I find as mean of four nights' results—

$$W = 0^s{\cdot}068 \text{ and } E = 0^s{\cdot}053\,;$$

and in the latter way—

$$W = 0^s{\cdot}066 \text{ and } E = 0^s{\cdot}050.$$

Dr. Albrecht has, in his above-quoted book, computed E from a number of observations; we have computed it from several others, and find that chronographic observations, on an average, give about $0^s{\cdot}04$ as the value for E, whether we compute W in one or the other of the above-mentioned ways. As the eye-and-ear method is now-a-days very seldom used for determinations of longitude, it does not furnish us with such rich materials for the calculation of E as the chronographic method does; the values for E ($0^s.06$, computed in the first way, and $0^s.05$, in the second way,) are, therefore, rather uncertain.

It does not seem that any considerable element of change enters into the personal equation by the passing from one night's observations to another. But we shall see afterwards that a personal error is not an absolutely invariable quantity, and it is, therefore, in any case, of importance to extend a determination of it over a greater number of nights. With respect to time-collimators, we possess too few observations to deduce a trustworthy value of E from them. But the artificial observations are certainly, in this respect, not essentially different from the real ones, as experiments made in Leyden and in Berlin have shown.*

II.

After having considered the different ways in which an observer's personal error, or two observers' personal equation, can be found, we shall now try to find what general results can be derived from the great number of observations and remarks upon this subject, which are scattered about in the annals of different observatories, and in papers about determinations of longitude, etc.

The first important question which is to be answered is, whether the error is constant or not? When we compare several values of an error, found at different times, with each other, of course, only such deviations can be considered as real variations, which are too great to be caused by the common uncertainty in a transit observation.† We have already mentioned the regular variation in the equation Bessel – W. Struve, which seemed to arise from changes in Bessel's large personal error. Another instance of such a regular variation is the eye-and-ear equation between Main and Rogerson in Greenwich.

In 1840 M. – R. was =	$-0^s.15$
1841	$+0.08$
1843	$+0.20$
1844	$+0.18$
1845	$+0.20$
1846	$+0.26$
1847	$+0.35$
1848	$+0.37$
1849	$+0.39$
1850	$+0.45$
1851	$+0.47$
1852	$+0.63$
1853	$+0.70$

* Albrecht, *l.c.* page 32.—The probable uncertainty E, for a single day, was found $= \pm 0^s.018$, while natural transits, taken by the same observers, gave $E = \pm 0^s.026$. The circumstance that a real star moves more unsteadily than an artificial one, may have contributed to make the latter value of E larger than the former one.

† Valuable investigations of the exactitude in transit observations have been

This regular variation is really surprising. There are several othe" examples to be found in the Greenwich observations, but none so striking as the above-mentioned one; for instance, the equation W. Ellis – Rogerson was—

In 1846	– 0^s·11
„ 1847	– 0 ·22
„ 1849	+ 0 ·12
„ 1850	+ 0 ·45
„ 1851	+ 0 ·36
„ 1852	+ 0 ·44
„ 1853	+ 0 ·62

From these two examples we learn that it was Mr. Rogerson whose error was gradually increasing in the course of years. On the other hand, there may be found examples of a nearly perfect immutability, but most commonly a personal equation will be found to vary a little, without following any distinct law. In order to illustrate how the relations of two observers can be at different epochs, I have promiscuously taken the following specimens from the Greenwich observations:—

EYE-AND-EAR METHOD.			CHRONOGRAPH METHOD.			
Year.	Dunkin and Henry.	Main and Henry.	Year.	Dunkin and Criswick.	Stone and T. Ellis.	Dunkin and Stone.
1841.	—	– 0^s·09	1855.	– 0^s·03	—	—
1842.	—	– 0 ·01	1856.	– 0 ·10	—	—
1843.	—	– 0 ·02	1857.	– 0 ·10	—	—
1844.	+ 0^s·30	– 0 ·05	1858.	– 0 ·08	—	—
1845.	– 0 ·15	– 0 ·12	1859.	– 0 ·13	—	—
1846.	0 ·00	– 0 ·05	1860.	– 0 ·14	+ 0^s·02	+ 0^s·07
1847.	+ 0 ·24	– 0 ·03	1861.	– 0 ·15	0. 00	+ 0 ·13
1848.	– 0 ·01	– 0 ·04	1862.	– 0 ·15	+ 0 ·01	+ 0 ·14
1849.	0 ·00	– 0 ·05	1863.	– 0 ·16	+ 0 ·02	+ 0 ·14
1850.	– 0 ·08	– 0 ·11	1864.	– 0 ·12	+ 0 ·04	+ 0 ·13
1851.	– 0 ·11	– 0 ·11	1865.	– 0 ·12	+ 0 ·06	+ 0 ·09
1852.	– 0 ·13	0 ·00	1866.	– 0 [illegible]	+ 0 ·12	+ 0 ·04
1853.	– 0 ·12	+ 0 ·03	1867.	– 0 ·13	+ 0 ·13	+ 0 ·02
1854.	– 0 ·17	—	1868.	– 0 ·10	+ 0 ·13	+ 0 ·05
			1869.	– 0 ·11	+ 0 ·17	+ 0 ·03
			1870.	– 0 ·11	– 0 ·01	+ 0 ·17

It has often been said, that a large personal error in many cases can, by practice, be reduced to a considerably smaller one. C. Wolf

undertaken by Pape (Astr. Nachr., liv.), Dunkin (Monthly Notices, R.A.S., xx., xxiv.) and Albrecht (Ueber die Bestimmung von Längendifferenzen, page 3).

reports, for instance, that, during the first three months he used his apparatus, he found an error = + $0^s\cdot3$, but that he, by constant practice, reduced it to + $0^s\cdot11$, at which rate it continued for more than six months.* He, therefore, recommends young astronomers to be "educated" by practising with the artificial apparatus, as large errors, eventually appearing in this way, may be diminished, when the observer has remarked their existence. Kaiser has been of the same opinion, and has always kept his apparatus ready for work. They have, however, been very little used,† and it is still doubtful whether such an "education" is of much use. Of course, the apparatus ought to be very carefully adjusted during such exercises, and experienced astronomers (who, it is to be supposed, are not in want of any such "education") ought to observe with them at the same time. It is not improbable that the personal error may be changed by practice, in the eye-and-ear method, as well as in the chronographic method; indeed, my own experience, however limited, makes me inclined to think so. We know that a perfectly unexperienced observer's error, within a very short interval of time, even on one and the same evening, has changed considerably;‡ and besides, an observer has often himself felt that he performed a certain act (for instance, the touching of the key) too early or too late, and when he has found this out, it is comparatively easy to correct the fault.§ But it seems to be but very seldom that such a case happens, and until experience has taught us otherwise, it must be considered as very doubtful whether an "education," such as the one above mentioned, is of much use.

It is certainly an unpleasant circumstance that personal equations and errors are often variable, as one may fear that the value used for the reduction of a series of observations is not the right one, if it is not found exactly at the time when these observations were made, which is not always possible; for instance, at determinations of longitude. The invention of the chronographic method was about twenty-five years ago hailed with pleasure, as it was expected that the personal error by this method should become more constant, as well as smaller.‖ But these expectations have only partly been realized,

* Annales de l'Observatoire de Paris, Mém., t. viii., p. 171.

† Annalen der Sternwarte in Leiden, ii., p. 26.

‡ In the Mémoires des Astronomes de Poulkova, t. ii.: Expéd. Chronom. de 1845, p. 52, there is mentioned a Lieutenant Alexandrow of the topographic corps, whose error (found by comparisons with the other experienced members of the expedition) varied enormously. It seemed as if A. only for a few hours kept the same custom in observing, but that his error changed (often $0^s\cdot3$ or $0^s\cdot4$) when there was a larger interval between the different observations. It was at first expected that A. by practice could become more regular, but this was not the case.

§ So, for instance, when the chronographic method was introduced in Leyden, (Kaiser, Verslagen, ii., p. 232). We shall afterwards see how an excellent observer, Schönfeld, in the course of years, has changed his way of estimating transits of nebulæ, when it had been remarked that his right ascensions were too small.

‖ W. C. Bond, in the Report of the British Assoc., 1851.

and in this respect the new method is not much superior to the old one, except that very large errors, as Bessel's, never have been found by the chronographic method. However, the personal equation or error by the new method is most commonly very different from that of the old one, as might be expected from the great difference between the two methods. The following examples show this:—

	Eye-and-Ear Method.	Chronograph Method.
Dunkin – Hugh Breen, . . .	– 0s·14	+ 0s·09
Dunkin – Henry, ...	– 0 ·17	+ 0 ·01
Dunkin – Todd,*	+ 0 ·01	+ 0 ·05
Criswick – Lynn,†	– 0 ·37	– 0 ·14
Weiss – Förster,‡.	– 0 ·27	0 ·00
Absolute personal error: Kam,	+ 0 ·16	– 0 ·03
„ „ „ Hennekeler,	+ 0 ·12	– 0 ·07
„ „ „ F. Kaiser,§	– 0 ·14	– 0 ·07

It is an advantage in the determination of absolute errors that one is able to see which of the observers changes his way of estimating transits, while a determination of personal differences only shows that one of the two observers (or both of them) has a different way of observing by the two methods.

Considering the importance of the question about the constancy of personal errors, especially in determinations of longitude, we shall here examine a case, in which this question was investigated in a very nice and remarkable way, which has hitherto not, I think, been noticed sufficiently. For the determination of the difference of longitude between Gotha and Leipzig the eye-and-ear method, as well as the chronographic method, was used by the two observers, Auwers and Bruhns.‖ On eight evenings the culminations of a certain number of standard-stars, observed with eye and ear, were by both observers compared with the registered culminations of another group of stars, taken from the same catalogue as the first stars, and the two groups were so arranged, that the uncertainty in the rate of the clock could have no influence. The clock-corrections, found by the two groups, gave a mean difference, which contained the difference in the errors of the right ascensions, the difference between the personal errors for one observer in using the two methods, and the interval between the moments in which the contact-apparatus of the pendulum in each

* Greenwich Observations, 1854, Introd.
† Greenwich Observations, 1859.
‡ Bestimmung der Meridiandifferenzen, Berlin-Wien-Leipzig. Vienna, 1872.
§ Verslagen, e. c. 2nd series, vol. ii., pp. 229-231. (Series C-G).
‖ P. A. Hansen: Bestimmung der Langendifferenz zwischen den Sternwarten zu Leipzig und Gotha, ausgeführt von C. Bruhns und A. Auwers. Leipzig, 1866.

movement marked the closing of the current on the chronograph, and the moments when the pendulum gave the audible second-beat. That the last-mentioned interval was constant was found with certainty by observing the two moments, when the coincidences of the beats of the two "assisting-clocks" (observed by the ear) with the beats of the principal clocks on both stations, also observed by the ear, and the coincidences of the contact-signals of the principal and assisting-clocks, registered on the same chronograph, took place. It was found in this way that, in a certain absolute moment, the difference, Leipzig clock-time *minus* Gotha clock-time, as found by the ear, was always a little less than the same difference, as found by the chronograph, and the mean deviation of the eight evenings, agreeing very well with each other, was found to be = $0^s \cdot 282$ (*l. c.*, p. 69). It appears from the single results that both observers (who twice exchanged their stations) agreed perfectly well in their estimation of the differences by the ear. But as the constant relation of the two time-scales to one another was proved, the personal error must necessarily have changed, if there appeared perceptible changes in the clock-corrections, found in the two different ways. And the following mean differences between the two clock-corrections were found :—

By Bruhns in Leipzig, $0^s \cdot 43$ (5 evenings).	By Auwers in Gotha, $0^s \cdot 42$ (5 evgs.)
,, ,, ,, Gotha, $0 \cdot 33$ (4 evenings).	,, ,, ,, Leipzig, $0 \cdot 75$ (5 evgs.)

According to Bruhns the difference between the registered and the heard clock-correction in Gotha was + $0^s \cdot 10$ different from the one in Leipzig; according to Auwers, + $0^s \cdot 33$. Above we have seen that the heard second-beats in Gotha came $0^s \cdot 28$ later after the registered ones than in Leipzig. We see now that the difference in estimating registered and heard culminations in Bruhns' case has changed $0^s \cdot 18$; in that of Auwers' only $0^s \cdot 05$.

This result controls very well the direct comparisons. By eye-and-ear was found :—

1865. April 12, in Leipzig, B.–A. = + $0^s \cdot 32 \pm 0^s \cdot 04$	(B. – A., in Leipzig).
,, October 2, ,, Gotha, ,, = + $0 \cdot 11 \pm 0 \cdot 03$	÷ (B. – A., in Gotha).
,, ,, 3, ,, ,, ,, = + $0 \cdot 19 \pm 0 \cdot 03$	= $0^s \cdot 17$.

We see that it was to Bruhns the change in the eye-and-ear-equation was due, and probably the explanation which the observers themselves give of the phenomenon is the right one. In Leipzig the clock gave double beats (with an interval of about one-third of a second between the single beats), and this had probably disturbed Bruhns, so that he perceived the moment midway between the two beats instead of the last one.* It is a pity that the personal

* The author has found a similar anomaly in himself by taking transits in a room, in which a mean-time clock and a sidereal one were placed.

equation in the chronographic method was determined only once, and a long time after (B. – A. = + 0^{s}·11, January 2, 1866) in Leipzig. In the determination of the difference of the longitude between Leipzig and Gotha, the personal equation was not eliminated by taking the mean between the results, found before and after the observers changing stations, but in the reduction of the series of observations during which B. observed in Leipzig, the equation found at this station was used, and likewise, in the reduction of the other series, the equation found in Gotha. According to the above-mentioned experiences, it would have been impossible to use the common method, which is only practicable when direct comparisons show that the personal equations between the two observers had not changed in the mean time. To change the stations without examining the equation at all (as in the determination of the difference of longitude between Berlin and Leipzig) seems doubtful.

Passing from the variation of the personal error, during longer intervals of time, and in the different methods of observing, we shall now consider a series of circumstances which, until a short time ago, were rather enigmatical, and have contributed a good deal to make many astronomers look upon personal equations as a very weak point in modern practical astronomy.* We allude to the changes in the personal errors, which often arise from *the reversal of the instrument*. In itself it sounds absurd that the position of the instrument should have any influence upon the error of the observer; but if we remember that a great number of such observations, for which several observers are wanted, and which accordingly require the determination of the personal equations, are made with transit instruments, with what is known as a broken telescope, the matter becomes different, because the direction of the star's passage through the field in such an instrument is different in its two positions. If we observe a star passing the meridian south of the zenith, it will, in both positions of the instrument, go from left to right through the field, but the inclination of the path to the horizon will be different, depending not only on the zenith distance, but also on the position. When the observer is at the eastern end of the axis, the star will go from the third quadrant to the first one, and when he stands at the western end, it will go from the second to the fourth. A star which culminates in the zenith will go vertically through the field, observed from east upwards, from west downwards. Between the zenith and the pole the motion will take place in a similar way from right to left.

We shall first consider the results obtained by artificial stars. C. Wolf has taken 11 groups of observations with his eye-and-ear apparatus, each group consisting of 40 transits; and by placing a prism

* From Bruhns' Biography of Encke we learn that the latter "felt disgust at personal equations" (letter to Gerling from 1855). Upon the whole Encke seems to have been rather sceptical with respect to the attainable exactitude in astronomical observations.

before the eye-piece, he made the star go horizontally in the same direction during 20 transits. The results are as follows:—

1864.	From Right to Left.	From Left to Right.
May 11	+ 0s·08	+ 0s·17
12	+ 0·11	+ 0·12
12	+ 0·09	+ 0·16
12	+ 0·13	+ 0·15
June 2	+ 0·12	+ 0·18
8	+ 0·11	+ 0·12
8	+ 0·10	+ 0·15
8	+ 0·10	+ 0·14
July 16	+ 0·09	+ 0·13
23	+ 0·08	+ 0·13
23	+ 0·09	+ 0·13
Mean	+ 0·10	+ 0·14

There is here a distinct though slight difference, and the mean result must be considered reliable, as the arrangement of the observations excluded the influence of faults in the apparatus.* Similar very small differences were found with Hirsch's apparatus (using the chronographic method).

Retrog. motion ÷ direct motion.	Plantamour	+ 0s·01	± 0s·02
	Rudolph Wolf	+ 0·04	∓ 0·01
	Hirsch	+ 0·06	± 0·03

It is remarkable that these small differences have the same sign as C. Wolf's.†

In Leyden there has been made a series of experiments with the second time-collimator, but only one of the observers found a slight difference which was very uncertain, as the chronographic method had only lately been introduced at the observatory.‡ Researches on this subject have also been made by Wagner, in Pulkowa, with a time collimator on Kaiser's principle, but his observations, which he has been kind enough to communicate to me, and of which we shall hear more further on, show no perceptible influence of the direction of the star's motion. We have heard of no other investigations of this kind except of a series of transits of artificial stars in perpendicular direction (analogous to transits of zenith-stars in a broken telescope), taken in Leyden, but the four observers, all of whom had a very small absolute error, found it to be a matter of no consequence whether the star was going upwards or downwards.§ Several observations of artificial stars,

* Annales de l'Observatoire de Paris (Mémoires) viii., p. 174.

† Détermination Télégraphique de la Différence de Longitude entre Righi-Kulm, Zürich et Neuchatel, Genève et Bâle, 1871, p. 187.

‡ Verslagen en Mededelingen der K. Académie von Wetenschappen, 2 ser., ii., p. 235.

§ Ibid.

moving along the line from left to right, under an angle of 45° and of 315° with the horizon, taken in Leyden and in Berlin, have given no difference at all between the two directions.*

The result of all observations with time-collimators seems to be, that it is never of any great importance in which direction the artificial star goes, as the difference in the estimation never exceeds a few hundreths of a second. If such a difference really exists (as in C. Wolf), it must arise from an unsymmetrical arrangement of the fibres of the nerves in the retina of the eye; and Wolf really found, by looking at two dots of ink, made on a piece of paper, at equal distances from both sides of a straight line, that the space between the line and the right dot always seemed to him, if he looked at it with the right eye, a little larger than the space between the line and the left dot. This experiment shows that he would always fancy the space between the wire in the telescope and a star to the right of it to be larger than it really was.

But in perfect opposition to these results were many observations of real transits, with broken telescopes, as by these differences of considerable size were often found. Weiss, for instance, remarked, in 1863, by reducing the observations for determining the longitude Leipzig – Dabletz, that the clock corrections were different, according to the position of the instrument. He and Bruhns found the following mean differences:†—

Obs. East *minus* Obs. West.

	Weiss.	Bruhns.
Eye and Ear	$-0^s{\cdot}17$	$+0^s{\cdot}07$
Chrongr.	$-0{\cdot}21$	$-0{\cdot}10$

The variation of the personal error with the position of the instrument (circle west and observer east, or circle east and observer west) may be seen by the following examples which are found in Dr. Albrecht's book about determinations of longitude (pp. 21–2). The observations were made by the chronograph, each observation comprising 5 wires:—

1. TRANSIT INSTRUMENT IN LEIPZIG, 25TH MARCH, 1867.

ALBRECHT – VALENTINER.		
West.	East.	West – East.
$-0^s{\cdot}33$	$+0^s{\cdot}45$	$-0^s{\cdot}78$
$-0{\cdot}39$	$+0{\cdot}49$	$-0{\cdot}88$

Each number is the mean result from 7 – 9 stars.

* The observations are given in Albrecht's Bestimmung von Langendifferenzen, Leipzig, 1869, p. 20.

† Astr. Nachrichten, lxviii., No. 1668.

2. Transit Instrument in Berlin.

Albrecht – Tietjen.				Albrecht – Valentiner.			
1867.	West.	East.	W. – E.	1867.	West.	East.	W. – E.
March 9	– 0s·27	– 0s·03	– 0s·24	July 13	– 0s·14	+ 0s·13	– 0s·27
15	– 0 ·18	– 0 ·03	– 0 ·15	14	– 0 ·14	+ 0 ·09	– 0 ·23
July 14	– 0 ·33	– 0 ·16	– 0 ·17	15	– 0 ·05	0 ·00	– 0 ·05
15	– 0 ·29	– 0 ·18	– 0 ·11	16	– 0 ·03	+ 0 ·05	– 0 ·08
16	– 0 ·28	– 0 ·14	– 0 ·14	Nov. 9	– 0 ·12	+ 0 ·09	– 0 ·21
Sept. 26	– 0 ·23	– 0 ·07	– 0 ·16	12	– 0 ·14	– 0 ·01	– 0 ·13
				27	– 0 ·05	+ 0 ·13	– 0 ·18

Tietjen – Valentiner.			
1867.	West.	East.	W. – E.
July 13	+ 0s·02	+ 0s·30	– 0s·28
15	+ 0 ·05	+ 0 ·31	– 0 ·26

Each number is the mean result of from 5 to 12 stars.

But the following results were found in Lund in Sweden, with the Leipzig instrument, after the illumination had been altered* :—

Valentiner – Bäcklund.			
1868.	West.	East.	W. – E.
June 26	– 0s·02	0s·00	– 0s·02
27	+ 0 ·02	0 ·00	+ 0 ·02
28	– 0 ·06	– 0 ·03	– 0 ·03
30	+ 0 ·03	0 ·00	+ 0 ·03

Each number is the mean result of from 6 to 12 stars.

Compared with these results, which are founded on numerous observations, the researches made in Greenwich in 1852 and 1853, with a "Binocular eye-piece," become of less importance, being founded on rather few observations, but they are of a similar nature. As already mentioned, this binocular eye-piece divides by a prism the rays coming from the object-glass of the transit-instrument into two parts, so that two observers simultaneously may observe a transit

* Bestimmung der Längendifferenz zwischen Berlin und Lund. Lund, 1870.

across all the wires. The transits look, of course, as if seen in a common broken telescope. We take as examples*:—

ROGERSON – DUNKIN.

1852.	D. east.	Stars.	D. west.	Stars.
Jan. 23,	– 0^s·69	4	– 0^s·52	4
April 2,	– 0 ·89	3	– 0 ·47	3
April 26,	– 0 ·65	3	– 0 ·21	3

DUNKIN – ELLIS.

1853.	D. east.	Stars.	D. west.	Stars.
Oct. 14,	0^s·00	3	– 0^s·21	3
Oct. 20,	– 0 ·01	3	– 0 ·17	3
Nov. 9,	– 0 ·08	3	– 0 ·19	3

We have now seen from a great number of instances that the different direction of the motion has no influence on the personal error in observations of artificial stars, but that the different position of an instrument with a broken telescope often has a very considerable influence on the estimation of the transits. It is impossible to explain this otherwise than by supposing the existence of a disturbing circumstance in the instrument itself. Already, eight or nine years ago, it was suggested, for instance, at the conference in Berlin, 1867, on the European measurement of arcs of meridian, that such a disturbance might arise from an eccentric illumination, causing an apparent shifting of the whole system of wires. The above-quoted observations, taken with the instrument of the Leipzig Observatory before and after the change of the illumination, show clearly how great an influence this had had. The matter was, however, not yet sufficiently examined, as long as it was unknown why the influence of the illumination was a different one for different observers. But the determinations of longitudes, which, during the last few years, were undertaken in Switzerland, have thrown light on these phenomena, and the investigations of Messrs. Plantamour, Hirsch, and Rudolph Wolf have considerably elucidated the question about the constancy of the personal error.

These three astronomers have taken the observations for the said determinations of longitude. The personal equation of the two first-mentioned was several times determined in the course of the years 1868 to 1870, and varied but little. But it was found in August, 1867, in Zürich, that the equation (Hirsch – R. Wolf) was now quite different to

* Greenwich Observations, 1852 and 1853 (introd.)

what it was a few months before in Neufchâtel. It was, therefore, supposed that there might be some cause for this change, and in order to obtain a certain value for his error, Wolf went in March, 1869, to Neufchâtel, and took, jointly with Hirsch, observations with the transit-circle for two days. But, strange to say, they now found almost the same result as that found two years before with the same instruments; besides, artificial stars had in 1867 given a value for the equation nearly midways between the two results of real transits which completed the confusion:—

H. − R. W.	$= -0^{s}\cdot162 \pm 0^{s}\cdot009$	by equator-stars	in Neufchâtel, May, June, 1867.
	$= -0\cdot067 \pm 0\cdot016$	,, artific. ,,	
	$= +0\cdot056 \pm 0\cdot009$	,, equator-stars	in Zürich, Aug. 1867.
	$= -0\cdot139 \pm 0\cdot013$	,, ,, ,,	in Neufchâtel, March, 1869.*

This was not the first time that such abrupt changes had taken place when the personal equation had been determined at different times with different instruments; but such a change had generally been explained by one of the observers using a strange instrument. For example†:—

Ernest Quetelet - Kam	$= +0^{s}\cdot60$	78 stars, tr.-circle in Leyden, August, 1868.
	$+0\cdot13$	artificial stars, ,, ,, ,, ,,
	$+0\cdot40$	transit-instr. in Brussels, September, ,,
	$+0\cdot16$	20 stars, mural-circle, Brussels, Sept., ,,

It was the variation of this equation which made Kaiser doubtful about his time-collimators, which seems strange, as the real transits differed just as much in their results. Another example is:—

Järnefält − Fuss	$= +0^{s}\cdot10$, June 27, July 4,	1870, Pulkowa.‡
	$+0\cdot41$, July 7–16,	

Although it was, therefore, nothing new that such strange results should appear in determinations of longitude, still, in the summer of 1869, Wolf undertook a series of researches in conjunction with his assistant, whereby it was found that the principal cause of the deviations between the different values was the position of the eye-piece. As is natural, when two persons observe immediately after one another the passages of the same star over the two halves of the system of wires, Hirsch and Wolf had placed the eye-piece midways between the two positions, which were convenient for their eyes; accordingly the eye-piece was for the short-sighted W. too far from the focus, but for H.'s normal sight it was too near this. Wolf derives the following results from all the observations printed in his "Mittheilungen," page 265:—

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* R. Wolf, Astronomische Mittheilungen, xxv. (Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, xiv., 1869, page 250).

† Annalen der Sternwarte in Leiden, ii., page 169.

‡ Bestimmung der Längendifferenz zwischen Pulkowa, Helsingfors, Åbo, Lowisa und Wiborg, von J. Kortazzi: St. Petersburg, 1871, pp. 68–9.

1. When the field of the telescope is illuminated from the west, upper transits are observed too early if the eye-piece is drawn out too far for the observer's sight, and too late if it is pushed in too much.

2. With eastern illumination the case is reversed; the transit is taken too late with the eye-piece drawn out, and too early with it pushed in.

3. If the field is illuminated by the diffused daylight, the position of the eye-piece has no influence on the personal error; and this error is also, on the other hand, independent of the direction of the illumination, if the eye-piece is exactly adjusted.

As during the above-quoted observations by R. Wolf and Hirsch, the eye-piece had always been drawn out too far for the sight of the former, it was now clear why he had observed too late in Neufchâtel, where the illumination came from the east, and too early in Zürich, where it came from the west.* Notwithstanding all this, the problem was not yet solved, as this effect of the position of the eye-piece and of the illumination was unexplained, and besides, how was it that Hirsch and the long-sighted Plantamour, in their numerous determinations of their personal equations, had never remarked such an effect? These questions were important enough to deserve a nearer investigation, and such a one was, therefore, made by Hirsch and his assistant, Schmidt, in Neufchâtel, during the spring of 1870, as follows†:— Each observer observed a certain number of stars over all the wires, having the eye-piece adjusted for his eye during the transit across half the wires, and having it drawn out or pushed in a little during the transit over the remaining half. The eye-piece was in either case moved to an equal distance from the normal position, and the part of the wires observed with the adjusted eye-piece was constantly exchanged for another. The observations, which are communicated in the "Astron. Mittheilungen," xxvi., gave the following results. By a we designate adjusted eye-piece, by d drawn out, and by p pushed in. The illumination came from the east:—

1870.	Number of Stars.	Difference between the Transits, reduced to the Central Wire.	Mean Error.	Observer.
April 20,	14	$a-d=+0^s{\cdot}259$	$\pm 0^s{\cdot}021$	S.
April 22,	10	$a-d=+0{\cdot}280$	$0{\cdot}019$	H.
April 25,	14	$a-p=-0{\cdot}276$	$0{\cdot}009$	S.
April 26,	15	$p-d=+0{\cdot}464$	$0{\cdot}011$	S.

* In both the instruments in use the illumination was from east or west sent down to the wires by a small mirror under an angle of 45° with the axis.

† Détermination télégraphique de la différence de longitude entre la station astronomique de Righi-Kulm et les Observatoires de Zürich et de Neufchâtel. Genève, 1871, pp. 171 and foll.

These numbers allow of no doubt as to the reality of the influence of the eye-piece: besides, the extent of this influence must be independent of the observer (as both H. and S. found nearly the same result), and it seems to be proportional with the distance of the eye-piece from its adjustment. The result found in this manner in Neufchâtel by illumination from the eastern end of the axis was identically the same as the one found in Zürich by illumination from the west, the transit having been taken too late, while the eye-piece was too near the wires, and too early, when it was too far from them.

The results were accordingly in perfect opposition to the observations taken in Zürich, and it seemed, therefore, that the placing of the lamp at one or the other end of the axis could not be the cause of the change in the anomaly. As the matter, therefore, seemed worth a closer examination, Hirsch took a series of observations with his artificial apparatus.* From these it was again seen that the day observations are independent of the position of the eye-piece, while the night observations showed not only again the influence of the eye-piece, but also that the variations are opposite when the lamp is placed east and west. And this time the influence of the illumination, strange enough, was the same as that in Zürich, and opposed to the one that only a few days previously had been found in Neufchâtel. For the transits were now observed with illumination from the east.

By H. too early	(on an average	0s·18)	with eye-piece	pushed in.
" S. " "	(" " "	0s·19)	" " "	" "
" H. " late	(" " "	0s·12)	" " "	drawn out.
" S. " "	(" " "	0 ·15)	" " "	" "

But observed with illumination from the west,

By H. too late	(on an average	0s·21)	with eye-piece	pushed in.
" S. " early	(" " "	0 ·24)	" " "	drawn out.

The question as to *how* the position of the eye-piece influences the observation seemed, therefore, to become more and more abstruse, while the existence of this influence was constantly felt if the field was illuminated by artificial light. What remained was to explain the contradiction between the Neufchâtel observations of natural and artificial stars, with respect to the direction of the influence (retarding or accelerating) for the same position of the lamp and the eye-piece.

An observation by Hirsch gave at last the key to all the phenomena. The apparatus for the artificial star was in Neufchâtel placed before the meridian-mark, and when the telescope was directed towards the latter, the middle of the field was seen strongly illuminated by the gas-flame behind it, so that the wire in the telescope, across which the transits were observed, was projected partly on this

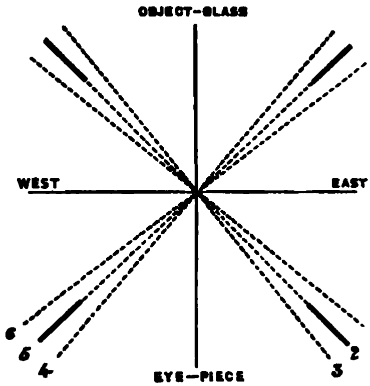
* Communicated in his "Différence de Longitude, Righi–Kulm," &c.

bright circle, partly on the dark border round it, where it was seen only by the field illumination in the telescope. The 3rd May, while the eye-piece was too far from the wire, Hirsch remarked that the latter was not seen as a straight line, but as a broken one, as the part which was seen on the bright ground seemed to be moved out of its place to the right. With adjusted eye-piece the line was seen straight; with a pushed-in one it appeared broken, and its central part moved to the left. And this apparent shifting of the wires was found to be independent of the placing of the lamp.

At once awakened to this fact, Hirsch soon remarked that an observer always would see two images of the wire if the eye-piece was not exactly adjusted; besides the principal one, which, from want of adjustment appeared diffused, a secondary, much fainter but sharper, image was seen. The latter image seemed to occupy the real place of the wire, and the relative position of the two images was reversed for the two motions of the eye-piece. This gave, evidently, the explanation of the principal fact, the acceleration or retarding of the transits, caused by the abnormal position of the eye-piece; and by measuring the distance between the two images, by means of a movable wire, this was found = $0^s{\cdot}29$, or nearly equal to the difference $a - d$ and $a - p$ on page 507.

This discovery, however, did not explain the observations made in Zürich, nor those taken in Neufchâtel on the 2nd May. It had been suspected that the position of the reflecting mirror in the telescope might influence the phenomenon, and this was confirmed by an observation of Schmidt on the 4th May. According to this, a change in the inclination of the reflector caused the secondary image to change its position. While the reflector (whose inclination could only be changed a little) was in an extreme position, he could see the image on the bright background of the meridian-mark, and the other one on the comparatively darker field-background; but on the latter he could not see the secondary image, which Hirsch had seen on the preceding day. This image, however, became visible when he turned the reflector a little to the right; it changed its place according to the position of the eye-piece, but without coinciding perfectly with the image projected on the bright back-ground. After the reflector had been turned still more towards the position in which it would give most light, there came a moment when the two images in the part of the field only illuminated by the reflector had the same intensity; when the reflector was turned still more in the same direction, the secondary image disappeared again, while the principal one became more distinct. It was also found that the distance between the two images decreased gradually, while the eye-piece was approached to the adjustment in which they coincide; by moving it beyond the normal position, the secondary image appeared again, but on the opposite side.

All these results were confirmed a few days later by MM. Plantamour and R. Wolf. The latter recapitulates the influence of the reflector in the following way :*—



Place of the Lamp.	Position of the Reflector.	Field.	Relative position of the image illum. by the reflector, with respect to the image on the bright ground.	
			Eye-piece drawn out.	Eye-piece pushed in.
West.	1	Bright.	To the right.	To the left.
—	2	Dark.†		
—	3	Bright.	To the left.	To the right.
East.	4	Bright.	To the right.	To the left.
—	5	Dark.†		
—	6	Bright.	To the left.	To the right.

We have here so fully described the results of the investigations of the Swiss astronomers, because it is evident that they are of very great importance, not only for our knowledge of the personal error, but for practical astronomy in general. They explain most probably the sudden changes in the equation of two observers, which have often been remarked, and they have, besides, confirmed the suggestion that the illumination of the wires causes the difference between the errors in the two positions of a broken telescope, which sometimes appear. Two of the weakest points in the art of observation have in this way been made clear. And it is easy to avoid the causes of the disturbances, now that they are known. If the observer has only adjusted the eye-piece according to his sight, he may be sure

* Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, xv., 1870, p. 249.

† Only so in the Zürich instrument, owing to the large aperture of the reflector.

that nothing but his common personal error will influence his observations.

After having considered the variation of the personal error during shorter and longer intervals of time, and the influence of the eye-piece on the estimation of a transit, we shall now turn our attention to two circumstances which may have a similar influence, the magnifying power and the apparent velocity of the motion of the star, varying according to its polar distance. These two circumstances have often been considered as perfectly identical. Bessel, for instance, tells us* that he, acknowledging the importance of the question as to whether the personal error varies according to the polar distance, had made numerous experiments with several powers, whereby it was found to be of no consequence whether he observed stars near the equator with a power of 180, or with one of 66; and as stars with a N. P. D. not smaller than 20°, seen with the former power, move as quickly or more quickly, than equatorial stars seen with the latter, he concluded that there was no fear of faults in his right ascensions arising from the difference in polar distance. But this conclusion is not quite certain, as C. Wolf has already remarked,† because the thickness of the wire is increased by a higher power, whereby it may be difficult to estimate its axis in like manner before and after the transit. It seems, therefore, more correct to treat the two questions separately; moreover, neither have been examined sufficiently hitherto. With respect to the magnifying power, the following tables show the few results hitherto published:—

I. Eye-and-Ear Method.

Power.	C. Wolf.
34	+ 0ˢ·163
43	+ 0 ·151
77	+ 0 ·111
133	+ 0 ·104

Power.	F. Kaiser.	P. J. Kaiser.	Kam.	van Hennekeler
50	− 0ˢ·094	+ 0ˢ·032	+ 0ˢ·188	+ 0ˢ·055
200	− 0 ·141	+ 0 ·018	+ 0 ·160	+ 0 ·125

* Königsberger Beobachtungen, viii., p. 8.
† Annales de l'Observatoire de Paris, Mémoires, t. viii., p. 175.

II. Chronographic Method.

Power.	F. Kaiser.	P. J. Kaiser.	Kam.	van Hennekeler
50	$-0^{s}\cdot094$	$-0^{s}\cdot096$	$+0^{s}\cdot028$	$-0^{s}\cdot074$
200	$-0\cdot067$	$-0\cdot051$	$-0\cdot029$	$-0\cdot084$

Power.	Plantamour.	R. Wolf.	Hirsch.
70	$-0^{s}\cdot063$	$-0^{s}\cdot243$	$-0^{s}\cdot154$
200	$-0\cdot039$	$-0\cdot170$	$-0\cdot134$

We see from this that the changes (if such appear at all) are very small, and there does not seem to exist any law, as it would probably be too early to say that a higher power decreases the error, considering the small number of cases.

With respect to the influence of the declination, there cannot at the present moment be said anything in general, as this important question has been very little examined. In itself, it is very improbable that personal equations should vary much according to the declination of the stars, as only the difference between the two observers' dependence could be visible. And there is no reason to expect that a personal error, generally, should vary regularly according to the apparent velocity of the star, as even in rather high declinations (50° or 60°) the space passed through by the star in a second is large enough to be divided with certainty. And that the error should increase with sec δ, as R. Wolf thinks has been found by the observations in Zürich,* does not necessarily result from them, and is besides very improbable, as personal errors must arise from faults in the sight, or in the hearing, or in the co-operation of these senses, and in the chronographic method, from faults in the pressing of the key. Faults of the latter kind, or in the hearing, must necessarily be the same everywhere; while faults in the sight, as already said, can hardly change until in very high declinations. C. Wolf's observations show certainly a regular but very small variation of the error, as the

* Astron. Mittheilungen, xxv. (Vierteljahrsschrift der Gesellschaft in Zürich, xiv.), 1869, p. 265.

following table illustrates, but they are the only ones which have given such a result.*

Velocity (the equatorial one = 1).	Personal Error.	Number of Complete Determinations.
1·9	+ 0ˢ·141 ± 0ˢ·014	6
1·5	+ 0 ·120 ± 0 ·010	8
1·1	+ 0 ·108 ± 0 ·012	5
0·7	+ 0 ·091 ± 0 ·015	6

Most probably a velocity greater than the equatorial one was strange to the observer, and therefore more likely to cause an increase of the error. But that personal errors might be quite different in observations of polar stars, has for along time been suspected, not only from Pape's and Peters' observations,† but for many other reasons. We shall here mention only the considerable difference between the determinations of the right ascension of the polar star by Bessel and Struve, which probably arose from a different error for equatorial and for polar stars. With still greater certainty must such a variation account for the great difference between Struve and Preuss, which appeared through Peters' researches on the right ascension of the polar star, from the observations in Dorpat. We know also from Newcomb's "Positions of Fundamental Stars," that the R. A. of the polar star has been found considerably different by the different observers in Washington; so that, for instance, Mr. Thirion differed more than two seconds from Professor Hall.

Astronomers who propose the construction of standard catalogues must therefore in future enter more fully than hitherto into an examination of their personal errors. Such a one has lately been undertaken by M. Wagner, Vice-Director of the Russian Central Observatory in Pulkowa, who has been kind enough to communicate to me his important results, of which I shall now, with his permission, give a short account.

When the chronographic method was introduced in Pulkowa, it was soon found that the right ascensions of polar stars not only depended on the observer's individuality, but also on the method of

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* Annales de l'Observatoire de Paris, viii., p. 187.

† The equation Pape – Peters was:

	Eye-and-Ear.	Chronograph.
for equatorial stars	– 0ˢ·11	– 0ˢ·14
„ the polar star	– 0·02	– 0·33

(Astron. Nachrichten, liv., p. 187.)

observing (that is, using the old or the new method), and that the appearing differences were a good deal larger than the probable errors of a single observation. Before deducing final results with respect to the positions of northern stars, it seemed therefore necessary directly to find the above-mentioned differences between the different principal observatories; or better, to determine the absolute personal errors by one of the artificial instruments. For the first reason, M. Wagner went in the summer of 1868 to Greenwich, where he, on seven nights, compared himself with the transit observers there; for the second purpose, a time-collimator was placed in one of the meridian-mark houses in Pulkowa, so that the transits of the artificial star could be observed by lenses of proper focal length, in the large transit instrument.

Polar stars are in Greenwich still observed with eye and ear alone. As the observations are taken by several observers, M. Wagner could only obtain mean results. While his equation with the Greenwich observers for equatorial stars was very small,* he found for stars near the pole:

N. P. D.	W. – Greenwich.	Number of Stars.
5° 12′	– 0ˢ·02	3
4 22	– 0 ·51	3
3 24	– 0 ·02	7
2 45	– 0 ·50	5
1 5	– 0 ·34	1
1 0	– 1 ·14	5

The negative sign and the increase towards the pole seems certain. This result became more interesting, when it appeared that some of the observers differed more than others. By adopting the expression

$$\Delta = \gamma \frac{\sin 2^\circ 45'}{\sin NPD}$$

the following differences were found:

$$\text{W.} - \text{Dunkin} = -\ 0^s{\cdot}56\ \frac{\sin 2^\circ 45'}{\sin NPD}$$

$$\text{W.} - \text{Ellis}\ \ = -\ 0{\cdot}\ 17\ \frac{\sin 2^\circ 45'}{\sin NPD},$$

the probable errors of the coefficients being respectively = ± 0ˢ·15,

* Greenwich Observations, 1868, Introd. (Dunkin – Wagner) = – 0·05 by chronographic observations.

and = ± 0^s·11. As it therefore seemed probable that the different observers would find different values for the R. A. of the polar star, M. Wagner, justly thinking it of interest to ascertain this, extracted from the volumes of "Greenwich Observations," published before 1869, the R. A. of α Ursae minoris separately from the observations of every single assistant. In order to be independent of the uncertainty in the azimuth, only such results were used, for which two consecutive culminations were observed by the same person. The following R. A.s for 1865·0 of α Ursae minoris were found in this way:

Dunkin,	$1^h\ 9^m\ 39^s$·19	from	58	observations.
Ellis,	38 ·54	,,	48	,,
J. Carpenter,	38 ·43	,,	30	,,
Criswick,	38 ·12	,,	44	,,
Kerschner,	37 ·82	,,	18	,,
Stone,	36 ·47	,,	8	,,

This has again confirmed the possibility of a different estimation of transits of polar and equatorial stars.

The observations of artificial stars in Pulkowa began in 1870. The apparatus used was the modified time-collimator of Kaiser, manufactured by Tiede in Berlin, and, as already mentioned, placed so that the circumstances under which the transits were observed were as much as possible like those under which the natural transits were taken. The following tables give the results of M. Wagner's observations. When the star was made to go more slowly, a less number of wire-transits were taken than when the star was going with the velocity of an equatorial star. The column δ indicates the apparent velocity of the artificial star.

1870. MOTION DIRECT.

log.sec.δ.	δ.	Error by Eye and Ear.	Error by Chronogr.	Number of Observations.	Chr. − EE.	(EE + Chr.)/2
0·02	17°15′	− 0^s·018	− 0^s·089	3½	− 0^s·070	− 0^s·053
0·12	40 40	− 0 ·001	− 0 ·063	7·6	− 0 ·062	− 0 ·032
0·46	69 43	+ 0 ·028	− 0 ·088	8	− 0 ·116	− 0 ·030
0·67	77 39	− 0 ·039	− 0 ·165	7	− 0 ·126	− 0 ·102
1·11	85 33	+ 0 ·05	− 0 ·12	3	− 0 ·17	− 0 ·035
1·21	86 28	+ 0 ·02	− 0 ·31	6	− 0 ·29	− 0 ·17
1·55	88 23	+ 0 ·22	− 0 ·30	7	− 0 ·52	− 0 ·04
1·76	89 0	+ 0 ·31	− 0 ·24	7	− 0 ·55	+ 0 ·03

1871. MOTION RETROGRADE.*

log. sec.	δ.	Error by Eye and Ear.	Error by Chronogr.	Number of Observations.	Chr.—EE.	$\frac{\text{EE.} + \text{Chr.}}{2}$
0·06	29°26'	− 0s·055	− 0s·061	7	− 0s·006	− 0s·053
0·41	67 6	− 0 ·28	− 0 ·085	8·9	− 0 ·057	− 0 ·057
0·67	77 39	− 0 ·001	− 0 ·112	8	− 0 ·111	− 0 ·056
1·15	85 57	+ 0 ·04	− 0 ·28	7·6½	− 0 ·32	− 0 ·14
1·50	88 11	+ 0 ·14	− 0 ·32	8	− 0 ·46	− 0 ·08
1·77	89 2	+ 0 ·46	− 0 ·02	8	− 0 ·48	+ 0 ·22

M. Wagner considers these results worthy of some credit, as the differences between his registered transits,† and those observed with eye and ear, agree very well with what has appeared from his observations of the real stars. The constant faults (caused by defects in the apparatus) can, for equatorial velocity, only amount to a few thousandths of a second; for the slowest motion, they may be considerably larger, on account of faults in the adjusting screws, but the mean results contained in the last column of the above table may, notwithstanding this, be considered as a very fair approximation to the truth.

The last question we now have to answer is, has the apparent brilliancy of the objects observed any influence on an observer's estimation of its transit? That a personality is distinctly visible in observations of the first and second limbs of the sun or the moon, has lately been shown by Mr. Dunkin, in Greenwich, in two papers laid before the Royal Astronomical Society,‡ the personal errors being detected in the tabular errors of the R. A. of the moon and of the sun. The different habits of observing these two celestial objects by the four principal observers in Greenwich, are essentially the same in the observations of both of them, as the following table shows:§—

* Corresponding to the direction of the motion of a star between the Pole and the Zenith.

† To be found in the column headed: "Chr. − EE."

‡ On Personality in observing Transits of the limbs of the Moon—"Monthly Notices," Vol. xxix., p. 259. On Personality in observing Transits of the first and second limbs of the Sun.—*Ibid.*, xxxv., p. 91.

§ For the moon Mr. Dunkin has not only used the observations taken with the transit-instrument (quoted here), but also those taken with the altazimuth, which, upon the whole, give similar results, although made under quite different circumstances.

TABULAR ERRORS OF R. A.

	Of the Sun.		Of the Moon.	
	1st Limb.	2nd Limb.	1st Limb.	2nd Limb.
Criswick – Dunkin, .	+ 0s·052	+ 0s·002	+ 0 s·034	+ 0s·032
C. – Ellis, ...	+ 0 ·103	+ 0 ·019	+ 0 ·112	+ 0 ·077
C. – J. Carpenter, .	+ 0 ·150	– 0 ·001	+ 0 ·132	+ 0 ·038

There can hardly be any doubt that this personality principally arises from the irradiation, as it is a well-known fact that the diameter of the sun, as well as that of the moon, is measured differently by different observers, as also by different telescopes. But there is another circumstance, the condition of the atmosphere and the quality of the images (which depends thereon) whose great importance for observations of such very luminous objects must not be undervalued. The observations of the sun made in Pulkowa by Wagner and Gyldén (especially by the former) show very distinctly that the apparent diameter of the sun increases, as the images get worse,* and the circumstances under which the limbs of the sun and the moon are taken differ therefore, in every respect, from those of star observations, so that personality in the former cannot be treated from the same point of view as in the latter.

While the observer's individuality thus has a different influence in observations of the different limbs of the sun and moon, we must leave it to the future to decide whether observations of faint stars, compared with those of brighter ones show a similar anomaly (that is, a change in the common personal error) or not. It is impossible to find anything respecting this question by examining any of the published observations of personal equations, as these only extend over three or four of the first classes of magnitude, where, no doubt, a distinct variation of the personal errors never will be found.

The matter is certainly of importance. If we suppose that an observer's personal error is not subject to very sudden variations (as we have seen is not the case with tolerably experienced observers), it will for common astronomical observations be of no importance whatever, how large his error is, if he only determines the correction of the clock himself. But the case becomes quite otherwise, if his error is different for stars of a different magnitude. If he, for instance, observes a zone of small stars of 8 to 9·10 mag., and uses

* Vierteljahrsschrift der Astron. Gesellschaft, viii., pp. 48–55.

a clock-correction derived from four or five standard stars, the different estimation of bright and faint stars will cause a constant fault of all the right ascensions of the zone.

In order to explain the deviations of Nyrén's constant of precession from those of Bessel and Struve,* we might seek the origin of the undeniable difference: Schjellerup – Bessel – Weisse = – 0s·095 in such a different estimation in one of the two observers, which would be more likely to have existed in Bessel's case, as Schjellerup's right ascensions can hardly be affected with any large constant error, considering their excellent agreement with those of the Göttingen zones,† which are founded on the same standard stars. Before leaving the Copenhagen Observatory, I tried to find whether the above difference could be explained in this way. From the original observations of Schjellerup's and the "Königsberger Beobachtungen," I wished to derive differences of right ascension between zone stars appearing in both catalogues, and standard stars, which the two observers would have had in common, if such had been observed together on one night in Königsberg, as well as in Copenhagen. But it appeared soon that any certain and reliable result could not be obtained in this way, as Schjellerup nearly always had used other standard stars (one or two classes fainter) than Bessel, so that only a very small number of zone stars occurring in both catalogues, could be compared with one and the same standard star. However, the difference between the right ascensions of the two catalogues has probably another and a deeper origin, as neither of the two constants of precession used now-a-days seems derived in quite a satisfactory way.‡ Besides, according to Argelander's comparison between Bessel's zones and Struve's "Positiones mediæ," it does not seem likely that the former are affected with any constant error as the one suggested above.§

It cannot, however, be doubted that a different estimation of transits of bright and faint stars may exist,‖ and an example has been found by Argelander by comparing Santini's fifth catalogue, containing positions of stars between 90° and 93° N. P. D., from observations

* Détermination du coefficient constant de la précession au moyen d'étoiles de faible éclat. Par M. Nyrén (Bulletin de l'Académie Imp. des Sciences de St. Pétersbourg, 1869).

† Göttingen – Schjellerup = – 0s·005 (R. Copeland und C. Börgen: Mittlere Oerter der in den Zonen – 0° und – 1° enthaltenen Sterne: Göttingen, 1869 (p. 13).

‡ Bessel has, for instance, used Lindenau's constant of nutation, which is 0″·25 too small, while O. Struve has founded his researches on his father's determination of the relation between the mean distances of stars from different classes.

§ Vierteljahrsschrift der Astron. Gesellschaft, vii., p. 17.

‖ Bessel has already suspected this (Briefwechsel zwischen Olbers und Bessel, ii., p. 358).

by Trettenero, with the catalogues of Schjellerup and Bessel. He found by dividing the stars according to the magnitude:*—

Magn.	Schj.−Tr.	Stars.	Δ'a.
6^m	$+0^s.023$	14	$-0^s.013$
7	$+0.031$	35	$+0.017$
7·8	$+0.089$	23	-0.022
8	$+0.084$	68	$+0.002$
8·9	$+0.105$	74	0.000
9	$+0.124$	120	0.000

The increase of the difference with the decrease of the brightness of the stars seems beyond doubt. The last column contains the deviations of the differences from the formula:—

$$\text{Schj.} - \text{Tr.} = +0^s.010 + 0^s.038\,[\text{Magn.} - 6^m.0].$$

The comparison between the Padua zones and those of Bessel gave a similar result, which, however, is more uncertain than the above one, owing to constant errors in some of Bessel's zones, uncertainty of proper motions, &c. Argelander informs us also that the third Padua catalogue has been found by himself to contain a similar deviation of the faint stars.

It seems, therefore, that Trettenero really observed faint stars earlier than bright ones, probably because his attention while observing the former was more concentrated in the work of the eye, or because he regularly first heard the beats of the clock, and then saw, while he observed bright stars in the reverse way. Argelander has already, in Vol. VI. of the Bonn Observations (p. 12), suspected that a fault in his own R. A.s might arise in this way, and he has later examined his own observations of variable stars, in order to find whether any certain influence of the magnitude on the R. A. would appear from these. The result was, that Argelander seemed to observe stars down to 9·1 magnitude in the same way, but stars of the magnitude 9·2, and still more those of magnitude 9·3, a little earlier; but that the error for the latter could hardly amount to more than $0^s.15$. For stars below the 9·3 magnitude, the accidental errors seemed to amount to more than the constant one, so that the latter could not appear distinctly.†

As observations of variable stars in their different phases of brightness are included in the programme of the zone observations, at present undertaken by different observatories, under the direction of the International Astronomical Association, we shall, probably, soon possess

* Vierteljahrsschrift, vii., p. 19. † Astron. Nachrichten, lxxiv., p. 268.

a number of trustworthy results respecting the personal errors of faint stars.

Closely connected with the question of personality in observations of faint stars is another important matter, to which the great number of nebular observations, made during the last twenty-five years, has turned our attention. We allude to the constant differences between the right ascensions found by different astronomers. It is especially Schönfeld, whose results, published in Vol. I. of the "Mannheim Observations," show a remarkable deviation from those of all other observers of nebulæ, as the following equations show:—

Schönfeld	– Laugier	= – $0^s{\cdot}21$.
	– d'Arrest	= – 0·38.*
	– Schmidt	= – 0·39.
	– Schultz	= – 0·30.†
	– Oppolzer	= – 0·38.†
	– Vogel	= – 0·21.

Although it seemed unquestionable that Schönfeld's right ascensions are too small, I thought it would be of interest to compare them with the "Micrometrical Observations of 500 nebulæ by Dr. Herman Schultz," which were published in Upsala, in 1874, in order to see, whether the very striking difference between the Mannheim and the few earlier Upsala observations would appear again, when all the observations of later years were employed in the comparison. It is safest only to compare objects which have been determined by both observers by means of the same comparison-star, as the small differences between the positions of the different star catalogues might produce here too great an effect upon the value of the small personal equation. Of the 163 objects which occur both in Schultz's and Schönfeld's observations, I, therefore, only took 114, which have been compared with the same star. Of these 114 the neb. h 393 could not be used, as it seemed most probable that a different point had been observed. The remaining 113 equal differences nebula-star gave for the equation Schönfeld – Schultz

$$\Delta\alpha \cos\delta = -0^s{\cdot}338.$$

As only thirteen nebulæ gave a very small positive value $\Delta\alpha$ cos, there is no doubt, that one of the two observers has a different way of estimating the transits of stars and nebulæ.

That these indications of personal equations in nebular observations

* Mean of all the comparisons contained in the "Observationes Havnienses." This number is, of course, of less value than the others, as d'Arrest only observed most nebulæ approximatively. The comparison between Schönfeld and d'Arrest's "First Series" (Leipzig, 1856) gave a similar difference, which, however, disappeared when only nebulæ observed with the same star were compared.

† Astron. Nachr., lxiii., No. 1504.

do not depend on instrumental circumstances, but really on the observer's individuality, can be proved in several ways. Although Schönfeld observed with an annular micrometer, whose construction, certainly, *may* give rise to constant errors, it is impossible in this way to explain the differences between Schönfeld and the other observers of nebulæ. Schmidt observed also with an annular micrometer, and still his observations differ about as much from Schönfeld's, as those of Schultz, made with a wire-micrometer. Between the right ascensions obtained with nearly equal telescopes, and by means of wire-micrometers in Leipzig and Upsala, I found, besides, a difference (Vogel – Schultz):

$$\Delta\alpha \cos\delta = -0^{s}\cdot10,^{*}$$

which agrees very well with the difference between the equations Schönfeld – Schultz and Schönfeld – Vogel $= -0^{s}\cdot34 - (-0^{s}\cdot21) = -0^{s}\cdot13$. But the second series of Schönfeld's observations, published only a few months ago, have made the reality of the influence of the observer's individuality quite unquestionable. This series contains 153 objects, which also occur in Schultz's observations, and the author has himself compared their R.A.s with those in Schultz's "Preliminary Catalogue of Nebulæ,"† which is less troublesome than the way of comparing chosen by me. The result is: ‡

$$\Delta\alpha \cos\delta = -0^{s}\cdot150,$$

while a comparison between this series and the first one gave

$$\text{I.} - \text{II.} = -0^{s}\cdot21.$$

These two comparisons agree most perfectly with my result given above, and show with certainty that Schönfeld, being aware of the fact that he made his right ascensions too small, or was inclined to observe transits of nebulæ too soon, in the course of years has altered his method of estimating the latter. This proves to some extent that the personal error is not perfectly independent of the individual's will, which must be considered as one of the most important results we hitherto have found respecting this abstruse subject.

My examination of Schultz's observations has given another result, which also, I think, is of some importance. Julius Schmidt had already, by comparing his own observations with those of Schönfeld, found the equation to be different according to the con-

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* From fifty-five identical differences: nebula star. I have already mentioned this equation, as well as the preceding one, in a review of Dr. Schultz's work in the Vierteljahrsschrift der Astronomischen Gesellschaft, x., pp. 64–73.

† Monthly Notices of the R. Astron. Society, xxxv., p. 135.

‡ Astronomische Beobachtungen auf der Sternwarte zu Mannheim, ii., Carlsruhe, 1875, p. 8.

densation and apparent size of the nebulæ (Astr. Nachr., Nos. 1463 and 1513), so that large and uncondensed nebulæ gave the greatest equation. But as the Athens observations are few in number, this result could not be very reliable. I, therefore, thought it of interest to see whether Schultz's comprehensive observations would show a similar dependency, when compared with those of Schönfeld. The result of my examination is found in the following two tables. As might be expected, the condensation of a nebula has more influence upon the estimation of the transits than its size.

TABLE I.

Nebulæ classified according to their apparent Size.

Class.	Diameter of Nebulæ.	$\Delta\alpha \cos\delta$.	Number of Nebulæ.
I.	0′·2 – 0′·6	– 0s·28	57
II.	0 ·6 – 1 ·5	– 0 ·36	22
III.	1 ·5 – 3 ·5	–0 ·40	20
IV.	3 ·5 – 8 ·5	– 0 ·46	14

TABLE II.

Nebulæ classified according to the Degree of Condensation.

Class.	Appearance.	$\Delta\alpha \cos\delta$.	Number of Nebulæ.
I.	Planetary, or with a starlike nucleus, .	– 0s·15	32
II.	Less condensed, more irregular, . . .	– 0 ·39	53
III.	Large & uncondensed,	– 0 ·44	28

We have now come to the end of our researches about the different circumstances under which personal equations and errors appear, and shall at last consider the probable origin of the phenomena.

III.

When Bessel had first remarked the considerable equation between himself and his pupils, in the winter of 1820, he tried at once to explain this remarkable phenomenon from the co-operation of the two senses, sight and hearing, which takes place when an observation is made by eye and ear.* If we suppose that impressions on the eye and ear cannot be compared instantaneously with one another, and that two observers take an unequal time to transfer the one impression to the other, there will arise a personal difference or equation, which will be still larger, if one observer begins with seeing and ends by hearing, and the other observer does the reverse.

There can hardly be any doubt that the explanation here intimated, in many cases, especially when the equation is of a considerable size, is the right one. In the eye-and-ear method the mind is in reality at work in three different ways: hearing, seeing, and counting the seconds; perhaps one might say in four ways, considering the expecting of the coming beats of the clock. The longer the interval between the beats, the longer time this expectation will of course take; and this is perhaps the reason why Bessel's personal error was found half a second smaller, by using a half-second watch, whose single beats were counted, so that he, with this watch, observed $0^s \cdot 494$ later than with a clock beating whole seconds, while Struve and Argelander found no such difference.† However, Bessel's very considerable error cannot be explained perfectly in this way. Encke has tried to explain it, simply by supposing that Bessel counted a second too early, and this certainly agrees with the decrease of the error by using the half-second clock.‡ C. Wolf is of the same opinion,§ and he tells us that a few years ago an analogous case occurred at the Observatory in Paris, where an observer noted all the transits one second later than all the others.‖ But although this proves the possibility of such a mistake, it hardly seems probable that Bessel's personal error should arise from such a very simple cause, and besides, how should we explain personal equations of $0^s \cdot 5$, $0^s \cdot 6$, $0^s \cdot 7$, of which we have several examples in the eye-and-ear method,¶ and how can an observer continually change his way of estimating transits in the course of years (in which case we could not think of a new way of counting the seconds)? We have already, in the foregoing, given several examples of such alterations, and the equation Bessel–Struve increased besides, continually, until it reached its maximum

* Königsberger Beobachtungen, viii., p. 7.

† This explanation of Bessel's error has already been suggested by Albrecht (Längendifferenzen, &c., p. 36). Several observers in Leyden observed in 1861 and 1862, with two chronometers, one beating single seconds, the other giving 130 beats in one minute; but none of them found any certain variation in their small errors, caused by the use of the latter (Verslagen, &c., xv., pp. 212 and 217).

‡ Monatsberichte der Berliner Academie, 1858, p. 617.

§ Annales de l'Observatoire de Paris, Mémoires, t. viii., p. 186.

‖ According to Radau (Sur les erreurs personelles, p. 29, Moniteur Scientifique, 1866), the said observer, to his great surprise, was convinced of his mistake by observing the disappearance of an artificial star behind a screen, and counting the seconds aloud, while another person (in the moment of the disappearance) gave him a slap on the back.

¶

Nehus – Wolfers	$= +0^s \cdot 73$ (1833).	Main – Rogerson	$= +0^s \cdot 70$ (1853).
Petersen – Mädler	$= +0 \cdot 52$ (1833).	Jacob – Sashoo Jengar	$= +0 \cdot 80$ (1858).
Gerling – Nicolai	$= +0 \cdot 78$ (1837).	Quirling – Lucas	$= +0 \cdot 67$ (1868).
Dunkin – W. Ellis	$= +0 \cdot 84$ (1847).	Main – Lucas	$= +0 \cdot 70$ (1868), &c.

value in 1823. Wolf proves his assertion by the fact, that the equation Bessel–Argelander, by occultations of stars, was found = – $0^s{\cdot}222$, but by transits = – $1^s{\cdot}222$. I do not understand this argument, as there is no reason why Bessel should count the seconds properly while observing occultations, but not when he observed transits.

Notwithstanding these but slightly proved objections to Bessel's explanation of his great error, nobody has attempted to deny the great influence of the "superposition" of the two senses on the appearance of the personal error. Faye has tried to elucidate the matter by a comparison.* We might imagine, he says, that the intellect was an eye in the interior of the brain, observing the effects which the impressions of the senses make in the fibres of the nerves. If impressions of the same nature are made in the same point, this interior eye can easily decide whether they are simultaneous or not; but if it should observe different perceptions, by fibres extending to different portions of the brain, the interior eye would have to move from one portion to another, the time spent in this movement would not be remarked, and perceptions divided by a real interval of time might therefore erroneously be considered as simultaneous. The time lost in passing from one perception to another is different in each individual, and in this way personal equations may arise. This is only a comparison, but a very good and instructive one.

We cannot, however, be satisfied with this, but we must examine the question more closely in order to see how a personal error can arise, both in the eye-and-ear method, and in the chronographic one. Let us begin by considering the different effects of the senses, and the time spent in their completion, as this time already gives the possibility of a personal error. There are three processes by which a perception is made: an impression on a receptive organ (the eye or the ear), the passing on of this impression through the nerves to the brain, and at last, the mind's perception.

It is quite clear that there must be some time lost during the two first processes, and this is besides proved in different ways. The impression on the receptive organ is quite material, and lasts some time; very brilliant objects are, for instance, visible to the eye a short time after this organ has been closed. That the passing on to the brain through the nerves requires time may be seen from direct experiments. Helmholtz has, for instance, found the velocity of the propagation of a nervous irritation equal to about thirty-four metres in a second,† so that the time lost in bringing an impression to the brain is often quite perceptible.

In like manner, a certain time must elapse before the material irritation causes the mind to be aware of what has happened. As we do not know at all how the perception arises, that space of time cannot be determined, but its existence can indirectly be felt if we determine the velocity of the sensation, or the time in which the mind can only be occupied by a single perception. We may determine this by

* Comptes rendus, t. lix., p. 475. † Poggendorf's Annalen, Bd. lxxix., p. 329.

seeking the minimum of time in which two different efforts of the mind can follow each other. We could, for instance, find the time which elapses between the observation of an instantaneous sound, or of a glimpse of light, or the touch of an external object, and the immediate completing of a galvanic current through the pressure of a key by the hand. Experiments to this effect have been made by Hirsch, Hankel, and others. On an average we can consider the velocity of the perception of a sound, of a glimpse of light, or of the sense of feeling = $0^s{\cdot}20$. This number contains the velocity of the propagation in the nerves, and, besides, the time which elapses between the arrival of the nervous irritation from the brain to the muscles of the fingers, and the contraction of these.* But as these intervals are very small, compared with the above numbers, they prove with certainty that a limited time is necessary for the accomplishment of the mental process.†

The above-mentioned experiments show that the velocity of the sensation contributes to the formation of a personality in the perception of a phenomenon, as the single observers did not find exactly the same results. In the chronographic method, where the eye and the hand work together, a different estimation of the coincidence of the star and the wire can be joined by a different way of pressing the key. The former circumstance seems to be of great importance, especially if we observe bright stars with instruments of small aperture, which often do not give sharply-defined images of the stars. In the eye-and-ear method the different velocity of perception may be joined by the "superposition" of the two active senses, as well as by a different manner of estimating the beats of the clock, perhaps, also, by the expectation of them; while the chronographic method only requires the action of two of the senses, the eye-and-ear method takes in reality four actions of the mind. One might conclude from this that personal errors in the chronographic method, within shorter intervals of time, change less than in the eye-and-ear method, and that greater variations do not appear as suddenly in the former as in the latter, in which greater variations may be expected even within shorter intervals. As we have seen in the foregoing pages, observations have in part confirmed this conclusion, and it is a fact that errors of such an extent as Bessel's, and some of the observers, mentioned in the note of page 523, have never been found in the chronographic method, which certainly proves the great influence the simultaneous working of the senses and the expectation of the beats of the lock have on our estimation of a transit.

A general theory cannot be given of the origin of the personal error. We can only point out different circumstances which contribute to the formation of a personal error, and there can be no doubt that

* By Helmholtz found = $0^s{\cdot}01$.

† If it is necessary to prove more fully the duration of an impression on the senses, we need only remember that glimpses of light or sounds which follow one another with shorter intervals than about $0^s{\cdot}05$, cannot be perceived as separate phenomena.

the cause of one observer's error is not the same as the cause of another observer's. Wolf tries, in the paper we have so often quoted, to give a general theory of the personal error, which, however, does not include the very large ones, with respect to which he contents himself with Bessel's explanation, simply adding, that constant practice may diminish them. He recounts so many ingenious experiments that this is sufficient reason for us to examine his ideas more closely, especially as several of his experiments show that the causes we have mentioned on the foregoing pages are certainly not the only ones which give rise to the personal faults.

We have already seen that Wolf's error in the commencement was found = + $0^s \cdot 3$, and that it was afterwards brought down by-and-bye to $0^s \cdot 1$, at which value it remained constant. In order to see whether this small correction arose from the confusion of hearing and seeing at the same time, he placed before the telescope a Geissler's tube, which gives a glimpse every second, and in this manner marked the time. One evening he found by common eye-and-ear observation of eighty angle transits, the error = + $0^s \cdot 11$, and by a series of observations with the tube, instead of the clock (intermixed with the former) the error = $0^s \cdot 10$. Another time the seconds were marked by the star itself, which, as an electric spark, blazed up every second, so that a sudden flash showed the position of the star in the field at the beginning of each second. By stopping his ears, in order to avoid hearing the noise of the spark, the error was found = + $0^s \cdot 08$, while common observations at the same time gave + $0^s \cdot 10$. Accordingly, Wolf's error was always constant, whether the observation was made by sight alone, or with the assistance of the ear. However, he tried in another way, whether "le temps mort" existed, as if so, its duration would depend on which organ was used. He substituted feeling for hearing by receiving light electric shocks in the left hand with a second's interval. Eighty transits of this kind gave his correction = + $0^s \cdot 11$ exactly the same as common observations.*

Having convinced himself that the simultaneous working of two senses could not give rise to his personal error, as it remained the same, whether one sense was working or the sight and the feeling co-operating, instead of the sight and hearing, Wolf produced by means of holes in a moveable board three artificial stars, situated one above the other, in a line perpendicular to the direction of their motion. The central star was always visible, the upper and lower one at the same time, but only for an instant, for example, regularly with a second's interval. There appeared, then, a remarkable circumstance, that at the moment the two outer stars flashed up the observer imagined he saw the central one had moved a little in advance of the other two, and this advance seemed proportional with the velocity. However, the foremost star always seemed to be furnished with a ray of light behind (reaching to the spot it should have occupied between

* Annales de l'Observatoire de Paris, viii., p. 189.

the other two) when the outer ones appeared with regular intervals; and it was only sharply defined, if these latter flashed up at irregular intervals. But if the steadily shining star had been caused to disappear at the moment when the others appeared, they were all seen in a straight line.

Wolf explains these phenomena in the right way, I think, when he says, that by the irregular sudden appearance of the outer stars, the eye, taken by surprise, is principally occupied with them for a moment, and in the meantime ceases to observe the central one, which can only be seen again after that moment, at a time when it has moved in advance. This last impression seems now to the mind to be simultaneous with the sudden appearance of the other two stars. But if they appear at regular intervals, the mind is prepared for their appearance, and the observation of the motion of the steadily luminous star is not perfectly interrupted during the sudden impression. While this lasts, the observer will therefore see all the places which the star has occupied, and it depends now entirely on his individuality as to which place he will select out of this series, and consider simultaneous with the sudden appearance of the outer stars. To conclude, from the sign of Wolf's personal error, he selected the place which was reached by the central star at the end of the sudden impression. But when the eye begins to see the flashing sparks, it retains all the positions which the central star successively occupied during a space of time equal to the duration of a luminous impression; it is, therefore, also possible that an observer imputes the position of the star in the moment of the flashing up to some point in this "parcours antérieur." Lastly, if we abolish the steady illumination of the central star, it is not possible to see a series of its positions during the sudden impression, and the personal error is done away with, at least for an anticipating observer.*

Such impressions on the senses, which, to the mind, seem to last for some little time (although their duration in reality is extremely short), must, according to the above, be of great importance as the sources of personal errors. Wolf tries on these experiments to found a theory for all kinds of personal equations in transit-observations, without being quite successful, as far as we can see. He remarks that the above explanation of personal errors, in case of our perceiving the seconds by the eye, cannot without alteration be applied to the eye-and-ear method, as a considerable difference between the duration of perceptions by the eye and by the ear has been found by his own direct researches, as well as by those of Helmholtz and Emsmann. If we perceive the seconds by the ear, the impression will certainly last for an extremely short time (less than $0^s{\cdot}01$), but owing to the

* Hartmann has found something similar by his apparatus (Grunert's Archiv. für Mathematik, xxxi., p. 17). If he placed a scale in the telescope and before the observation remarked at which division the star should be at the second-beat, he often fancied when he concentrated his attention on the motion of the star, that he saw it a little in advance of its real position. He oftener saw it in the right place when he was tired.

duration of the luminous impression, we will, during this short time, see the star, not only in its real place, but also in all the places it has occupied during an interval equal to the duration of the luminous impression.

It does not seem possible that there can be any objection to this; but in order to account for those errors by which the position of the star is anticipated, Wolf supposes that the transient impression from the place which the star really occupies in the moment of the second-beat, also may allow the mind to impute the following positions which the star occupies during this, to the instantaneous audible second-beat as simultaneous with it. This last supposition seems a little difficult to understand.

As we, therefore, cannot fully adopt Wolf's theory, we must be content to consider the question about the origin of the personal errors, as elucidated in different ways by the foregoing. In order to give a short review of what we have already said, we may mention among the principal causes producing personal errors: the co-operation of the different senses; the expectation of the regularly returning beats of the clock; the different velocity of the sensation; and lastly, the difference of habit in the mechanical actions.

Appendix.

Since the above paper was read before the Royal Irish Academy, Professor Bakhuyzen kindly sent me some results of observations made by himself and the assistants at the Leyden Observatory, which confirm several conclusions arrived at in the foregoing pages. It deserves, for instance, our attention that observations of Polaris by day and by night have again shown the considerable influence which an eccentric illumination of the wires can exercise over the personal error. That this is the only circumstance through which it is possible to account for the anomalies which so often have appeared in observations with a "broken telescope," has anew been proved by Dr. Valentiner's and Dr. Becker's observations with the time-collimator, as the different direction of the motion of the star was found to have very little or no influence on the personal error.

Observations have been made in Leyden in order to try whether the observers estimated the transits of bright and faint stars differently. The observations which were taken with the meridian-circle and chronograph gave the following results:

	Stars 3 – 6 magn.	Stars 8 – 9 magn.	Bright–faint stars.
Valentiner – Becker	= – $0^s \cdot 30$ (12 stars),	– $0^s \cdot 21$ (15 stars),	– $0^s \cdot 09$.
Valentiner – H. G. Bakhuyzen	= + 0 ·13 (34 stars),	+ 0 ·18 (53 stars),	– 0 ·05.
Valentiner – E. F. Bakhuyzen	= – 0 ·16	– 0 ·17	+ 0 ·01.

The difference in the equation Valentiner–Becker for bright and for faint stars has been confirmed by the zone-observations of stars between 30° and 35° northern declination made in Leyden.

XLV.—ANALYSIS OF COALS AND IRON-STONES FROM THE DUNGANNON COAL-FIELD, CO. TYRONE. By EDWARD T. HARDMAN, F.C.S., &c., of the Geological Survey of Ireland.

[Read February 28th, 1876.]

ANALYSES of one or two of the coals of Dungannon have been already published by Sir Richard Griffith,* and Sir Robert Kane.†

During a stay of over a year in the neighbourhood, while making a survey of the coal-field, I had opportunities of obtaining good average samples of all the more important coals at present being worked, and having examined them, I now propose to place the results before the Academy.

I have already, elsewhere, published more or less detailed descriptions of this coal-field,‡ and shall enter no further at present into what would only be repetition than to say that the coal measures there, although occupying but a small area, are about 2,000 ft. thick, and contain from 22 to 24 coal seams; all of them of fair, and some of excellent quality. These vary in thickness from 10 in. to 9 ft.

Appended is a list of the more important of these coals in order:

TABLE OF THE COALS AT PRESENT BEING WORKED.

Dungannon Coal-Field.

		ft.	in.
Middle Coal Measures. (*Coal Island series*).	Annagher Coal,‡	9	0
	Bone Coal,	2	10
	Shining Seam,	3	0
	Brackaville Coal,	5	0
	Gortnaskea Coal (with 22 in. cannel),‡	6	0
	Beltiboy Coal,‡	3	0
	Derry Coal,‡	3	6 to 5 ft.
	Yard Coal,	3	0
Position uncertain.	Creenagh Coal ‡ (with 14 in. cannel),‡	4	6
Lower Coal Measures. (*Drumglass series*).	Main Coal of Drumglass,‡	4	10 to 6 ft.
	Lower „ „	1	6 to 2 ft.

Those marked with an asterisk are included in the following analyses, being the only seams which were worked upon when I was in the district.

* Geological and Mining Surveys of Tyrone, &c. (Dublin, 1839), p. 12. These analyses are unfortunately nearly useless by reason of misprints.

† Industrial Resources of Ireland.

‡ See "On the Present State of Coal Mining in the Co. Tyrone." By Edward T. Hardman, in Jour. Roy. Dub. Soc., Vol. vi., part 42, p. 366. Also "Geological Structure of the Tyrone Coal-fields." Report Brit. Assoc., 1874, Belfast.

By the kind permission of Professor Galloway, the analyses were for the most part performed in the very complete laboratory under his control at the Royal College of Science, Dublin.

Analyses of the Coals of the Dungannon Coal-Field.

Lower Coal-measures.

No. 1.—*Main Coal or Drumglass Coal.* Lurgaboy (Top).

Analysis.

Volatile matter (including sulphur and water),		48·00
Coke	Fixed carbon,	47·43
	Ash,	4·57
		100·00

Water at 212° F.,	2·49 per cent.
Sulphur,	2·80 ,,
Ash in coke,	9·05 ,,
Specific Gravity,	1·295

Heating Power.—1 lb. of the coal evaporates 12·86 lbs. of water at 212° F.; and 1 cubic ft. of the coal evaporates 1109·68 lbs. of water at 212° F.

The above forms the uppermost portion of the main seam. It is an extremely good coal, not yielding in quality to the best English specimens. Although somewhat hard, and occasionally difficult to kindle, it burns with a very brilliant flame, abounding, as it does, in gas-forming materials. The ash is small in quantity, and light coloured. The heating power is very high. This portion of the seam varies in thickness from 1′4″ in Lurgaboy, to 1′10″ in Drumglass, and nearly 3′ in Congo, and is separated by a band of black shale or fire-clay called "*clearing*," which is three feet thick in Lurgaboy*—from the bottom coal.

No. 2.—*Main Coal.* Lurgaboy (Bottom).

Analysis.

Volatile matter, including sulphur and water,		37·19
†Coke	Fixed carbon,	51·53
	Ash,	11·28
		100·00

†Water at 212° F.,	5·72 per cent.
Sulphur,	1·65 ,,
Ash in coke,	17·95 ,,
Specific gravity,	1·385

* Towards the west of the Coal-field the "*clearing*" diminishes to a couple of layers, a few inches thick only.

† Mean of two experiments.

HEATING POWER:—1 lb. of the coal evaporates 12·15 lbs. of water at 212° F.; and 1 cubic foot of the coal evaporates 1043·32 lbs. of water at 212° F.

This portion of the coal is of rather inferior quality, as it contains layers of shale or slate, sulphate of lime, &c. The ash is large in quantity, and of a heavy, dirty, red appearance. The heating power is, however, high, and it is on the whole a good strong coal, very useful for furnaces, &c.

The next coal of value above this is the *Creenagh coal,* which is made up of several portions, the section being:—

	ft.	in.
Upper "soft coal," . . .	1	10
Cannel coal, ...	1	2
Cracker, ...	0	4
Lower, "soft coal," . .	1	2
	4	6

No. 3.—*Creenagh soft coal.* From Castlestuart Colliery, Creenagh.

ANALYSIS.

Volatile matter, including sulphur and water, .		43·40
Coke,	Fixed carbon, ...	39·80
	Ash,*	16·80
		100·00

Water at 212° F., .	7·46 per cent.
Sulphur, ...	1·94 ,, *
Ash in coke, . . .	21·30 ,,
Specific gravity, .	1·452

HEATING POWER.—1 lb. of the coal evaporates 10·45 lbs. of water at 212° F.; and 1 cubic foot of the coal evaporates 930·75 lbs. of water at 212° F.

The Creenagh soft coal is rather tender, but is sometimes obtained in large blocks. It is, however, very ashy, and contains many layers of sulphate of lime, which both add to its weight and deteriorate the quality. The ash is heavy and dirty, and the heating power is lowest of any seam in the district. It is at the same time a useful coal, and in good demand in the neighbourhood.

It may be mentioned that the pit from which the specimens used in the above analysis were obtained was very wet, owing to the encroachment of water through a fault. This will probably account for the extreme amount of hygroscopic moisture estimated.

* Mean of four experiments.

No. 4.—*Creenagh Cannel Coal.* From Castlestuart Colliery, Creenagh.

ANALYSIS.

Volatile matter, including sulphur and water,		52·87
Coke,	Fixed carbon,	34·18
	Ash,	12·95
		100·00

Water at 212° F,	3·20 per cent.
Sulphur,	1·94 ,,
Ash in coke,	30·02 ,,
Specific gravity,	1·396

HEATING POWER:—1lb. of the coal evaporates 12·37lbs. of water at 212° F.; and 1 cubic foot of the coal evaporates 1070·64lbs. of water at 212° F.

This coal is an extremely valuable band, and although thin, has been worked very profitably, fetching large prices. In quality and yield of gas, it is considered much superior to Wigan cannel, and equal to the best Lesmahago coal. Appended is part of a report written for Messrs. Young, formerly owners of the colliery, Castlestuart, Creenagh, by Dr. Wallace, Gas Examiner to the City of Glasgow, whose determination of the proximate analyses closely resembles my own (see note below).*

MIDDLE COAL-MEASURES.

No. 5.—*Derry Coal.* From Mr. King's Pit, Annagher, Coal-Island.

ANALYSIS.

Volatile matter, including sulphur and water,		26·43
† Coke,	Fixed carbon,	55·57
	Ash,	18·00
		100·00

Water at 212° F.,	Not estimated.
Sulphur,	,,
Ash in coke,	24·65 per cent.
Specific gravity,	1·499

* ANALYSIS OF CREENAGH CANNEL.—BY DR. WALLACE.

Volatile matter containing 0·76 sulphur,			47·68	
Coke.	Fixed carbon,	33·49	49·26	carbon in coke, 68 per cent.
	Sulphur,	1·12		
	Ash,	14·65		
Water at 212° F.,			3·06	
			100·00	

Gas per ton at 60° F., and 30" Bar., ... 11·600 cubic feet.
Illuminating power in standard sperm candles, . . 34·09
Dr. Wallace considers it could be made to yield even as much as 14·000 cubic feet per ton.

† Mean of two experiments.

HEATING POWER.—1 lb. of the coal evaporates 12·65 lbs. of water at 212° F., and 1 cubic foot of coal evaporates 1125·06 lbs. of water at 212° F.

This coal is now only worked in two pits in the townland of Annagher, where both in quality and thickness the seam has greatly deteriorated, according to the reports of those who have been engaged working it. The specimens obtained were of very poor appearance, being dull, slatey, and lumpy, and composed of thin bands of coal alternating with layers of shale and sulphate of lime. The seam is 3′ to 3′6″ thick. Only a partial analysis has been yet made. The ash is plentiful, and of a dirty, red colour, and the coal contains much iron pyrites (sulphide of iron).

It is remarkable that this coal has such a high heating power, considering the very large amount of ash it contains. But as much of the ash consists of iron oxide, resulting from the ignition of the iron pyrites, so abundant in the coal, some of the heat is, no doubt, due to the combustion of the sulphur in the pyrites.

No. 6.—*Beltiboy Coal.* From Mr. Slone's pit, Gortnaskea.

ANALYSIS.

Volatile matter, including sulphur and water,		49·40
Coke,	Fixed carbon,	48·17
	Ash,	2·43 *
		100·00

Water at 212° F.,	4·30 per cent.
Sulphur,	1·52 ,,
Ash in coke,	4·86 ,,
Specific gravity,	1·266

HEATING POWER.—1 lb. of the coal evaporates 12·82 lbs. of water at 212° F.; and 1 cubic foot of the coal evaporates 1006·25 lbs. of water at 212° F.

This is the next workable coal above the Derry coal, but between them, in 50 yards or so, there are 4 or 5 thin coals of very good quality which have been occasionally wrought at the outcrop. The Beltiboy coal is about a yard thick, or 3′6″ sometimes, and like most coal seams, consists of several bands of various quality; some parts have even been used for gas.

No. 7.—*Gortnaskea Coal.*

Above this coal comes the Gortnaskea seam, a coal 6 feet thick, including 22 inches of cannel at the top. I have only been able as yet to make a partial analysis of the cannel. In appearance, however,

* Two experiments.

this is an extremely fine coal, quite equal, if not even superior, to the Creenagh cannel.

Ash, ...	4·06 per cent.
Specific gravity, . .	1·232

It is rare to find a cannel coal with such a small percentage of ash.

Next in succession comes the Brackaville coal, the Shining seam, and the Bone coal.* Those I could not obtain specimens of, as the two former were not being worked when I was in the district; the last coal I saw in a new pit, on old workings, and it may give some idea of the expensive style of mining there when I mention that a fortnight after the pit-men opened it, it was found untenable on account of the water from the old workings, and other causes. As I had deferred collecting specimens until the solid coal should be reached, I was disappointed in obtaining any. The seam is 2′6″ to 3′ thick.

A few yards above this lies the Annagher coal. This seam is in most places 9 feet thick, and is an extremely fine bed; a soft, rich, black coal, full of gas, containing a mere trifle of ash, and but little sulphur. It is very difficult to work on account of its having a very thick bed of soft fire-clay for a seat. This often swells up, and makes the levels quite impassable.

The samples from which the analyses were made were obtained at a small "Gin Pit," sunk on the outcrop of the coal in Annagher. The pit was only 14 yards deep, and mostly in drift.

No. 8.—*Annagher Coal.* From a small pit in Brackaville.

ANALYSIS.

Volatile matter, including sulphur and water, .		45·62
Coke,	Fixed carbon, ...	52·46
	Ash, ...	1·92
		100·00

Water at 212° F.,	9·89 † per cent.
Sulphur, . . .	2·56 ,,
Ash in coke, . .	3·55
Specific gravity, .	1·250

HEATING POWER:—1 lb. of the coal evaporates 12·48 lbs. of water at 212° F.; and one cubic foot of the coal evaporates 967·20 lbs. of water at 212° F.

The above analyses will give a very fair idea of the character of the coals in the Dungannon Coal Field; and it will be seen that many of these will bear favourable comparison with the best

* Could this name be merely the French *Bon?* It is not improbable that the name may have been applied by Ducart, an Italian engineer, who worked these mines 100 years ago, especially as it *is* a coal of superior quality.

English coal in point of purity and heating power. They are all highly bituminous, and yield such a quantity of gaseous matter that any of them, except the Derry coal, might be used with great advantage in Ireland for gas manufacture, with profit, both to the colliery owner and to the gas company: a point which ought to be thought of if, as I hope, these coals some day come to be properly and extensively mined.

The heating power is extremely high; 10 to 11 lbs. of water evaporated is considered very good work for 1 lb. of coal; nearly all these give over 12, the best of them very nearly 13 lbs. The heating power was determined directly by Thompson's very elegant and simple apparatus. This is both more exact than the methods of calculation from the ultimate composition, or by actual experiments with a furnace and boiler, and infinitely more convenient than the latter process.

The analyses show that several of these coals contain an excessive amount of water, *e. g.*, the Creenagh, Annagher, and Bottom Lurgaboy coals. This, however, is, I think, entirely due to the state of the pits; the specimens from the two former seams being obtained from pits literally swimming in water, which were either surrounded with old workings, or only on the very outcrop of the coal. It is not unlikely that under more favourable conditions this item would be much diminished; and it must be remembered also, that none of the pits at present being worked on the coals enumerated herein are sunk on the best portions of the seams, or under anything like favourable arrangements.

One thing worth noticing in these coals is the complete proportion between their specific gravity and the amount of ash they contain. It has been a subject of no little discussion as to whether there is any relation between the amount of ash and the specific gravity, and I find it stated in Knapp's Technicology * that no direct connection can be deduced. However, Professor Johnson, a well-known American geologist and chemist, is referred to as believing "such to be the case with coal from the same coal-field, and considers the specific gravity to be an index of the purity of the coal. In analysing anthracites from Beaver Creek, Luzerne County (Pennsylvania), he found in four varieties the following relative quantity of ash:—

†BEAVER CREEK, PENNSYLVANIA.

	Specific Gravity.	Ash per cent.
1	1·560	1·28
2	1·594	4·00
3	1·613	5·01
4	1·630	5·063

* Knapp's Chemical Technicology. Drs. Ronald's and Richardson, vol. 1, pt. 1, p. 47–8 (1855).

† It must be remembered that the specific gravity of anthracite is always higher than that of bituminous coal.

In the coal from the basin of Maryland, bordering on Pennsylvania, a similar result was obtained. The coals are bituminous.

MARYLAND COAL BASIN.

	Mean Sp. Gravity. Two Specimens.	Mean amount Ash Two Specimens.
1	1·320	7·52
2	1·350	9·58
3	1·360	10·35
4	1·385	11·75
5	1·485	14·41

My analyses show a very close agreement in this respect with some of the Maryland coals, as will be seen from the following Table:—

DUNGANNON COAL-FIELD.

		Specific Gravity.	Amount of Ash.
1	Annagher coal, . . .	1·250	1·92
2	Beltiboy ,, . . .	1·266	2·43
3	Gortnaskea coal, cannel,	1·232	4·06
4	Lurgaboy top coal, . .	1·295	4·57
5	Do. bottom coal, .	1·385	11·28
6	Creenagh coal, cannel,	1·386	12·95
7	Do. soft coal, . .	1·452	16·80
8	Derry coal, ...	1·499	18·00

With the exception of the Gortnaskea cannel, which slightly breaks the series, this increase of ash with that of the specific gravity is extremely well marked here. Some of these, compared with those determined by Professor Johnson, exhibit an agreement that is very striking indeed. It is useless comparing the anthracite coals, for, as I have already remarked, the specific gravity is always higher, *cæteris paribus;* but I have given below some other analysis of bituminous coals, and they agree fairly well in the relation between the specific gravity and the amount of ash.

BELLEVILLE DISTRICT, ILLINOIS.*

	Specific Gravity.	Ash.*
1	1·293	4·50 to 5·40
2	1·296	8·60
3	1·315	8·90
4	1·340	13·01

* Coal Regions of America. J. Macfarlane, M.A., p. 425.

INDIANA COAL-FIELD.*

Specific Gravity.	Ash.
1·176	0·3
1·230	2·0 to 3·0
1·264	2·5
1·28	6·5
1·29	4·5
1·32	6·0

OHIO.—BLOCK COAL.

In six analyses the specific gravity ranges from 1·247 to 1·284.
And the ash from, ... 3·18 to 1.16.
Apparently reversing the matter. However, both the range of ash and of the specific gravity is very small here.

Among English and Scotch coals, as well as other Irish coals, a tolerably fair relation seems to exist in this way, as the following examples will show.

Name of Coal.	Sp. Gr.	Ash.	Where Published.
Scotch (Fordel Splint), .	1·25	4·0	Coal Fields of Great Britain. Prof. Hull, p. 406.
Newcastle (Cans. Hartly,	1·25	5·0	
Alfreton, Derbyshire, .	1·235	2·04	Chemical Technicology. Drs. Ronald and Richardson. Vol. i., pt. ii., Analytical Table, p. 1.
,, Cannel, . . .	1·278	4·64	
Liverpool Coal, . . .	1·260	4·62	
Newcastle-on-Tyne Birtley	1·270	4·00	
Ballycastle, Ireland, . .	1·273	4·20	Laboratory Notes, Mus. Ir. Ind. Technicologist. 1864.
Lough Allen, Leitrim, .	1·336	7·52	Do. do.
Do. do. . .	1·369	7·63	Do. do.
Do. do. . .	1·382	17·7	L. Studdert, LL.D., "Jour. Rl. Geo. Soc. I.," Vol. iii., p. 135.

So far then, it would appear, that within certain limits the specific gravity of a coal is a tolerably fair guide to the quality of it. For instance, one would not be far wrong in putting down a coal of 1·35 specific gravity as containing over 10 per cent. of ash, while one of 1·25 would be almost free from it.

IRON-STONES.—In the shales and fire-clays of the middle series of the Tyrone coal-measures there is a good deal of iron-stones, which occur both in beds and nodules, the former, in one or two instances,

* *Op. cit.*, p. 401.

from 1 to 2 feet thick, the latter abundant. None of them have been ever worked to any extent so far as is known.* They have the usual composition of clay-ironstone, and contain about the average per centage of iron. I have examined some of them, but only for the amount of iron, and the presence or absence of sulphur and phosphorus, as a more complete analysis would add nothing interesting to our knowledge of such minerals. The specimens were all obtained from the neighbourhood of Coal-Island.

ANALYSES OF IRON-STONES, DUNGANNON COAL-FIELD.

No. 1.—Thin seam of ironstone from above the SHINING SEAM.

Metallic iron, . . 35·50 per cent.
Neither sulphur nor phosphorus present.

No. 2.—Iron-stone nodules above GORTNASKEA COAL.

Metallic iron, . . 34·40 per cent.
Neither sulphur nor phosphorus present.

No. 3.—Iron-stone nodules above BELTIBOY COAL.

(*a.*) Metallic iron, . . 32·50 per cent.
Neither sulphur nor phosphorus.

(*b.*) Metallic iron, . . 21·70 per cent.
No sulphur: a trace of phosphorus.

(*c.*) ? Black band ironstones.
Metallic iron, . . 23·50 per cent.
No sulphur: a trace of phosphorus.

No. 4.—Iron nodules above DERRY COAL.

Metallic iron, . . 28·80 per cent.
No sulphur: no phosphorus.

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* Traces of an old iron furnace are found in the townland of Derry, near the road leading from Derryvale to Stewartstown, and a quantity of slag lies about. It is possible, therefore, that some of the iron-stones above the Derry coal were formerly smelted.

XLVI.—On a Case of Polydactylism. With Plates 36, 37, 38, and 39. By J. E. Kelly, Surgeon to the Jervis-street Hospital, Lecturer on Anatomy and Physiology, &c., &c.

[Read 14th February, 1876.]

The peculiarities which I have noted were observed in the body of a female, aged about 45 or 50, spare, with good muscular development, and anatomically a *virgo intacta*. She presented no other external congenital peculiarities besides those represented by the casts exhibited, except that she appeared to have had a strabismus, and her incisor teeth projected almost directly forward. The right hip afforded an excellent example of a traumatic dislocation of very long standing, with contraction of the acetabulum, atrophy of the head of the femur, remarkable development of ligamentous tissue anteriorly and inferiorly, and a fissure in the capsular ligament leading to the abnormal receptacle for the head of the femur, which was a smooth cavity under the gluteus medius muscle (no trace of the gluteus minimus remaining), lined by a glistening membrane which, at that part over the dorsum ilii, covered a very dense layer of fibrous tissue. The psoas muscle was represented by a thin cord of fibrous tissue, but the iliacus and all the other muscles about the joint were well developed. The arterial system was highly developed, and cutaneous vessels, ordinarily imperceptible, attained a remarkable size; both ulnar arteries were of the aberrant type, and lay over the fascia in their course. Both stylohyoid muscles were absent; the left renal vein passed posteriorly to the aorta; the vermiform appendix was about five inches long, and dilated towards its termination. I observed no other peculiarities worth noting except those affecting both hands and the left foot.

The hands were both heptadactylous, and the left foot was an example of spurious tridactylism, owing to the double syndactylism which had occurred. The supernumerary digits were on the radial or volar side of the hands, and may be regarded as cases of reduplication of the pollex. This was indicated by the length and direction of the metacarpal bones, the muscular attachments, and the vascular and nervous relations. The points of opposition for the digits of the right hand were three: the apex of the first thumb or the spine; the dorsal surface of the head of the first phalanx of the second thumb; and the distal extremity of the third thumb. On the left hand there was but one point, the head of the first phalanx of the second thumb, off which the next (second) phalanx was dislocated. Over these points were developed bursæ, and the cuticle was thickened.

The Bones of the Right Hand:—

The lower end of the radius normal. The ulna:—On the apex of the styloid process was a facet which articulated with the os triquetrum and the unciform.

The scaphoid:—Defective at that part normally articulating with the trapezoid.

The semilunar:—Prolonged very much to ulnar side, where it articulated with the entire of the inter-articular fibro-cartilage—a very large facet for the unciform.

The cuneiform:—Indistinguishable as a separate bone.

The pisiform:—Also indistinguishable.

The trapezium had an additional facet at the site of the external angle, for articulation with the first metacarpal bone. The groove on the anterior surface indistinct. Another facet for the "anterior trapezoid."

The trapezoid posterior:—Very large, extending upwards to the level of the head of the os magnum, which it resembled. A constriction was indicated at the level of the ordinary bone, and the additional portion seemed to be borrowed from the scaphoid, which was deficient to a corresponding extent. The bone did not reach the anterior surface of the carpus.

The anterior trapezoid(?):—About the size of a large pea; wedge-shaped, with the base anteriorly occupying the position of the anterior surface of the trapezoid proper. It articulated above with the posterior trapezoid and the scaphoid, below with the third metacarpal bone (that of the index finger), and latterly with the trapezium and the os magnum.

The os magnum:—The head was not rounded on the outer side; an additional facet for the anterior trapezoid.

The unciform:—Large, no process; a very large facet for the semilunar bone, and another on its anterior and upper surface for the os triquetrum.

The "os triquetrum":—Situated anteriorly to the unciform and the ulnar extremity of the semi-lunar bone, internal to which one of the angles projected backwards, and presented its apex on the posterior surface of the carpus. It presented two surfaces, three margins, and three angles. The surfaces were both rough, and had triradiate depressions, indicating the fusion of the bones; the inner or ulnar surface gave attachment to the hypothenar muscles, the outer or radial entered into the formation of the anterior carpal concavity. The anterior margin gave attachment to the annular ligament; the superior edge had attached to it a very strong radio-triquetral ligament. The posterior margin was divided into two parts: the inferior narrow, and attached by a ligament to the anterior surface of the unciform, corresponding to the position of the process; the superior portion broader, with an articular facet for the unciform bone. The anterior angle was tubercular, and gave attachment to the tendon of the flexor carpi ulnaris. The posterior angle had a smooth facet for articulation with the apex of the ulnar styloid process, and it also gave attachment to the internal lateral ligament. The inferior angle had attached to it ligaments extending to the bases of the last two metacarpal bones.

The metacarpus consisted of six bones :—

I. Two facets on base for trapezium and second metacarpal; head, round and articular.

II. Two facets on base for trapezium and first metacarpal; the head expanded and indicating a tendency to subdivision; one large facet for both phalanges.

III. Deficient in its normal characters as second metacarpal bone; five facets on base, the additional one for the anterior trapezoid.

IV., V., VI., normal, or rather corresponding to the third, fourth, and fifth metacarpals.

Phalanges :—That on first pollex, and the terminal on second pollex, ended in a spine, and bore no nails; nails were developed on all the other fingers.

The Bones of the Left Hand :—I shall only allude to those which differ from the corresponding bones of the right hand, as both members presented the same general peculiarities.

The scaphoid :—Very large. It seemed to have attached to it the portion which was in excess in the trapezoid of the right hand, and here also a constriction indicated the fusion of two bones. This disputed portion, or complemental process, in the right hand, was attached to the scaphoid by a very strong interosseous ligament.

The trapezoid :—Comparatively small.

The os triquetrum :—In two segments, the upper and lower, the latter resembling the unciform process in size, position, and attachments. It was bound to the unciform bone and to the upper segment by strong ligaments; no indication of a synovial articulation. In every other respect the bone resembled that in the right hand.

The metacarpus :—

I. Instead of having a head with an articular facet, as on the right side, ended in a spine which was capped by a cartilaginous ferule; a rudimentary phalanx, which was separated by a synovial cavity, and gave attachment to some of the muscles.

II. Base articulated with first and third, as well as with the trapezium. The head articulated with only one phalanx.

All the digits except the first pollex bore nails.

III. As before mentioned, the base articulated with that of II., an abnormality which did not occur in the right hand, and of much anatomical interest.

Phalanges :—First phalanx of third pollex was rounded off at its proximal end, and attached by a dense fibrous cord to the side of the metacarpo-phalangeal articulation of pollex two, where there was a normally placed sesamoid bone on the inner side. Another sesamoid bone was in the fibrous cord.

The second and third phalanges of the same pollex (three) were united, but their original separation was indicated by a node, and by the difference in the direction of their axes.

The Muscles of the Right Hand: Anterior Surface :—Flexor carpi radialis and ulnaris, normal; palmaris longus, absent; p. brevis, normal; flexor sublimis and profundus digitorum, normal; lumbricales, normal.

Musculus access. ad lumbricalem primum :—A slip about the size of a lumbricalis arose from the deep surface of the annular ligament by a tendon; inserted with the first lumbricalis.

Flex. pol. long. :—Origin normal; the tendon divided at cleft between second and third pollices into two slips, which were inserted into the third or terminal phalanges, and gave off slips to the contiguous sides of the bases of the second phalanges of their respective digits.

Abductor pollicis :—Origin normal; insertion, in two parts: one into the base of the terminal bone of the first pollex, on its inner aspect; the other, by a narrow tendon, which ran along the same side of that bone to its apex, where it ended in a fibrous cap. Action, to abduct and flex first pollex.

Opponens pol. :—Origin normal; insertion into the radial edge of the metacarpal bone of first pollex.

Adductor pol. :—Origin normal; insertion into the base of first phalanx of third pollex.

Flex. brev. pol. :—Only one head, the deeper; origin normal; two insertions: the first into the outer edge of the metacarpal bone of first pollex, close to its head; the second, into the base of the first phalanx of the third pollex. The first portion might be regarded as an add. pol. primi.

Transversus manus :—Origin, the anterior surfaces of the metacarpal bones of the middle and ring fingers, and the adjacent metacarpo-phalangeal ligaments; the two slips united, and were inserted into the base of the first phalanx of third pollex, on the inner side.

Mus. access. ad transversum manus :—Origin, the fibrous tissue giving common insertion to the numerous muscles inserted into the base of the first phalanx of third pollex, on its inner side; insertion, radial side of base of first phalanx of second pollex.

Interpollicaris :—Three slips :—First: origin, inner side of first phalanx of third pollex; insertion, outer edge of metacarpal of first pollex, where it was overlapped by abduct. pol. prim. and oppon. pol. Second slip: origin, anterior metacarpo-phalangeal ligament of third pollex; insertion, inner side of base of terminal bone of first pollex, and the anterior surface of its metacarpal bone. Third slip (interosseous): origin, from anterior surface and inner edge of metacarpal of first pollex; insertion, into base of first phalanx, and by tendinous slips into base of second phalanx of second pollex.

Flexor pol. secundi et tertii :—Origin tendinous, from the trapezium and the anterior trapezoid. It divided into two fleshy bellies, which were inserted into the bases of second and third pollices.

The Muscles of the Left Hand: Anterior Surface :—All the long muscles normal, except the flexor pol. long., the tendon of which divided at cleft between second and third pollices: one part went to second pollex, and at head of first phalanx divided into three slips, the central of which passed on to the terminal phalanx; the two lateral were inserted into sides of base of second phalanx; that part of the tendon going to the third pollex was inserted into the base of the terminal phalanx.

Lumbricales:—The first was very large, and divided into two slips: one had the normal insertion; the other, into the first phalanx of third pollex (lumbricalis ad pollicem tertium ?).

Abductor pol.:—Origin normal; three insertions: first, into anterior surface of metacarpal of first pollex; second, into an aponeurotic arch extending from the apex of first pollex to base of first phalanx of second pollex; third, partly into base of first phalanx of second pollex, and partly into the aponeurotic arch.

Oppon. pol.:—Origin normal; insertion into radial edge of the metacarpal bone of first pollex, and tendon of extensor oss. metacarp. pol.

Add. pollicis:—Origin normal; insertion into base of first phalanx of third pollex, and slightly in that of second pollex.

Flex. brev. pol.:—Three origins: two corresponding with the heads of the normal muscle, the third from base of metacarpal bone of third pollex. Insertions, four—first, into outer edge of first pollex; second, into the inner edge of the same bone; third, by a small tendon into the cartilaginous ferule on the apex of first pollex; fourth and largest (consisting of the entire of the portions from the trapezium and annular ligament, and that from the base of the metacarpal bone of pollex three), inserted into base of first phalanx of third pollex. The third head was separated from the rest of the muscle by the deep palmar arch.

Musculus access. ad trans. manus:—The transversus manus was absent, but I have applied the term "accessorius" to this muscle, owing to its similarity to that muscle in the other hand, in origin and insertion; but it differed in position, as it overlapped the interpollicares, while the others lay under these muscles.

Interpollicaris:—Two slips, both wedge-shaped, with their apices reversed. First, superficial; origin, fleshy, from base of first phalanx of second pollex; insertion, tendinous, into inner side of metacarpal bone of first pollex. Second slip: origin, from inner edge of metacarpal bone of first pollex, and its anterior surface; insertion, into the base of the first phalanx of second pollex.

The Muscles of the Right Hand: Posterior Surface:—Supinator long. and extensor carp. longior, normal; ext. carp. rad. brev. sends slip to base of metacarpal bone of index finger; ext. carp. ulnaris, normal.

Ext. digitorum communis:—The tendon to the index finger was small, and ended in the tendon of ext. indicis; none to the little finger.

Ext. min. digit.—Sends a slip to aponeurosis over the last interosseous space.

Ext. oss. metacarp. pol.:—Origin normal; course normal; divided into two slips, as is frequently seen: one inserted into base of metacarpals bone of first pollex; the other, into the base of the terminal bone of same (ext. internod pol. primi).

Ext. prim. internod. pol.:—Origin normal; insertion into base of second phalanx of second pollex. An aponeurosis from the tendon of last, and from the bone close to its insertion, passed this tendon, to the majority of the fibres passing over it.

Ext. secundi int. pol.:—Origin and course normal; joined with tendon of last muscle to form a common tendon, which divided at the cleft between second and third pollex. The portion corresponding to this muscle divided at head of first phalanx of third pollex into three slips: the middle passed over the joint, and was inserted into base of terminal phalanx; the two lateral were inserted into the base of second phalanx. This is the reverse of the arrangement with ordinary dorsal digital aponeurosis, and approximates to the flexor arrangement of tendon.

Ext. indicis:—Origin normal, but prolonged up as far as the attachment of the supinator brevis; course normal; insertion normal; tendon joined by small slip from ext. com. dig.

The Muscles of the Left Hand:—Posterior surface: supinat. long. and extensors of the carpus, normal.

Extensor com. digitorum:—Divided into two tendons only, which went to the middle and ring fingers; no trace of a tendon to the index or little finger.

Extensor ossis met. pol.:—Origin normal; divided into three slips: first, inserted into base of metacarpal bone of first pollex (ext. oss. met. pol. prim.); second, into cartilaginous nodule, at apex of first pollex, which is the homologue of the terminal bone of first pollex on right hand (ext. internod. pol. prim.); third, into an aponeurosis on the back of the first phalanx of second pollex, which was formed by the tendon of this and three other muscles (ext. primi internod. pol. secund.) Between the two tendons last mentioned a web of dense fascia extended, which was closely connected with both, and resembled the structure described in the right hand. The concave margin constituted the arch into which were inserted some of the short muscles of the anterior group.

Ext. primi internod. pol.:—Origin normal; insertion into the same aponeurosis as last.

Ext. sec. internod. pol.:—Origin normal, divided into two tendons; the external much the larger, inserted together into the same aponeurosis as last two muscles. This aponeurosis, formed by union of the four tendons, expanded towards the head of the first phalanx, and formed a cap which enclosed it, and was inserted into the base of the second phalanx.

Ext. indicis:—Origin normal; insertion normal. It received no slip from ext. digit. communis.

The Arteries of Right Hand:—The ulnar artery gave off a posterior carpal and a communicating branch, and then passed across the palm to the radial side of second pollex, along which it continued as its external digital artery. The superficial palmar arch was completed by a very large superficialis volæ, which lay superficial to the muscles of the thenar eminence. The arch sent a branch to the inner side of the little finger; one, before mentioned, to the outer side of the second pollex; and branches to the clefts between all the digits except to that between second and third pollices, which received a transverse branch which subdivided, from that between the third pollex and the index finger. The radial side of first pollex got a branch from the radial artery, while in the intertendinous space; while the other side received a branch from the superficialis volæ.

The radial artery wound round the wrist, passing under a distinct tendinous arch to the back of the hand, whence it passed forward between the second and third metacarpal bones. It distributed its usual branches, and certain others which might be termed dorsalis pollicis primi, d. p. secundi, and d. p. tertii. The deep palmar arch was small. This description suits the left radial artery also.

Left Hand:—The ulnar artery, as in the right, crossed to the radial side of pollex two. It was completed by a similarly placed superficialis volæ, which, however, was much smaller than the right, and gave off an equal number of branches, which were similarly distributed, except that the digital artery between pollex two and three was given off from the outer of the two branches supplying the compound digit. A remarkable branch, larger than either the radial or ulnar artery, passed under the annular ligament, with the median nerve, and joined the superficial palmar arch. Apparently, this was a very large arteria mediana from the interosseous artery.

The Nerves, Right Hand:—The ulnar: the superficial portion normal, the deep branch supplying all the short muscles, except the abductor and opponens pollicis.

The median nerve:—The inner division supplied the middle finger and the contiguous sides of the index and ring. It received no communicating branch from the ulnar. The external division supplied the radial side of the index finger, both sides of second and third pollices, and the ulnar side of first pollex. The radial side was supplied by a branch from the radial nerve which came from the back of the wrist. A distinct branch ramified between the second and third pollex, but the vascular supply was only collateral. On the posterior surface of the hand the posterior branch of the ulnar supplied two and a-half fingers; the remainder received branches from the radial nerve.

The Left Hand:—The same description is applicable to the nerves of this member, with a few trivial exceptions. The ulnar sent a communicating branch to the median, and the latter nerve, in addition to supplying, as in the right hand, the opponens and abductor pollicis, also sent filaments to the superficial portions of the flexor brevis pollicis.

The Foot:—The left foot, having but three distinct digits, was a specimen of double syndactylism, as well as of talipes valgus. The anatomy of this member presented few peculiarities. The normal arches of the foot were obliterated, and the most projecting portion of the tarsus was the anterior tubercle of the os calcis.

The Muscles:—Extensor brevis digitorum: insertions; first and third normal, second and fourth into the base of first phalanx of corresponding toe. Peroneus longus: inserted into a well-marked tubercle on the outer side of the os calcis, which most probably represented its own sesamoid bone. A fibrous band was continued from this tubercle to the normal insertion of the muscle.

Tibialis anticus:—A slip from the tendon of this muscle passed forwards to be inserted into the head of the first metatarsal bone.

In the Vessels nothing peculiar was observed.

The Nerves:—The anterial tibial, in addition to the normal branch between the first and second toes, sent a much larger branch directly to the space between the second and third toes, where the separation was complete. The fusion between the toes was most marked at their anterior extremities.

Synovial cavities were developed between the heads of the first, second, third, and fourth metatarsal bones. An articulation also existed between the bases of the first and second metatarsal bones.

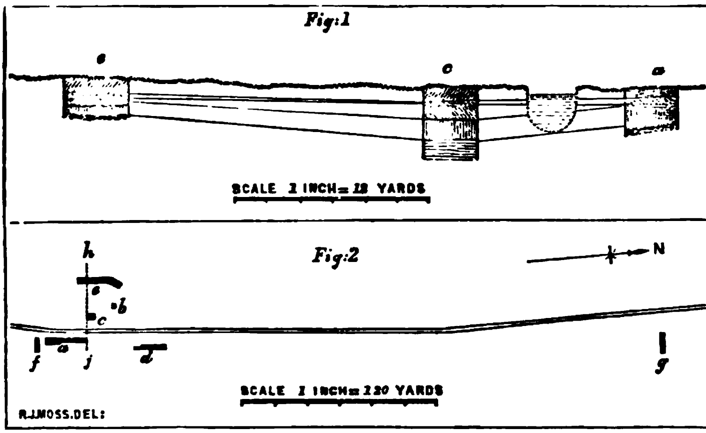
XLVII.—Report on the Exploration of Ballybetagh Bog. By Richard J. Moss, Keeper of the Minerals, Royal Dublin Society.

[Read April 10, 1876.]

About thirty years ago the late Mr. Sigismund Moss, of Kilternan, discovered an extensive deposit of the remains of the Cervus Megaceros, in a cutting which was made through the boggy land on the south side of Ballybetagh House, in the parish of Kilternan, county Dublin. In addition to the great horned deer, only one other animal, the reindeer (Cervus tarandus), was represented amongst the remains found. The fine specimen of the horns of this animal discovered on this occasion is now in the Museum of the Royal Dublin Society. The cutting in which these remains were discovered was made for the purpose of turning the water of the spring known as the White Well, into the stream that flows through Kilternan, and not with any scientific object; and thus it happened that no accurate account of the discovery has been published, and therefore it has had but little scientific value. Professor A. Leith Adams and I visited the locality early last summer, and at his suggestion I undertook to re-investigate the matter in conjunction with Dr. Carte, of the Royal Dublin Society. The ground being in the possession of the Rev. Mr. O'Sullivan, of Leopardstown, we applied to him for permission to conduct the investigation. This he most liberally granted, and I take this opportunity of expressing our thanks to him.

Ballybetagh Bog lies at the bottom of a glen, between two hills, running almost due south from Ballybetagh House. The lower of the two hills is on the east side of the glen; it is 700 feet above the sea level, and about 100 feet above the bottom of the glen. The hill on the other side of the glen is one of the range of the Dublin mountains. The rock of this district is granite, being part of that band of granite, about five miles broad, which extends from the south coast of Dublin bay, in a south-westerly direction, into the county Waterford.

The first difficulty encountered was rather formidable. No trustworthy information could be obtained as to the precise spot in which the remains had been found; it might have been any place along a cutting half a mile in length. The opinions of old residents in the neighbourhood were obtained, but were very contradictory. Not wishing to trust entirely to tradition or chance, I decided upon making an attempt to probe the ground at different places along the sides of the old drain. For this purpose I obtained an iron tube, twelve feet in length by two inches in diameter; it was longitudinally bisected, the two halves being held together by end-pieces screwed on, while a movable iron collar clasped the middle of the tube. The end-piece was sharpened to enable it to be driven into the soft earth, this being done by means of the apparatus employed for sinking the so-called Abyssinian pumps. After a few trials in various places along the side of the old drain—now quite full of water—I obtained a compressed section, which appeared to correspond with the strata said to overlie the bones of Megaceros (Oldham, Journal Geol. Soc., Dublin, vol. iii., p. 252). Here, accordingly, a trench was commenced, seventy feet long, and from nine to twelve feet broad (fig. 2, *a*). This trench is represented in section at *a*, fig. 1. The direction in which this



section is taken is indicated by the dotted line *h, j*, fig. 2. The first foot of material removed consisted of peat; under this there was a stratum of sand of an average depth of about two feet. The sand lay upon a brown-coloured clay, which extended for about two feet, and lay upon a bed of rounded granitic boulders. The spaces between the lower parts of the boulders were filled with a fine bluish-grey clay. Amongst the boulders, and surrounded with the brown clay, we found nineteen skulls of Megaceros, with the attached antlers greatly broken; also many broken pieces of horn, and a number of bones. The heads and horns were huddled together promiscuously, often so tightly locked together that there was some difficulty in removing them from their rocky bed. In many cases they were securely wedged between the boulders, and generally so situated that they could only be extricated by raising them directly upwards; some part would have been broken by any attempt to move them laterally. The smaller bones were found by carefully examining between the boulders after the heads had been removed. On several of the granite boulders I noticed a net-like coating of vegetable matter, closely resembling matter contained in the cavities of many of the skulls. This is so decomposed that I fear it is impossible to determine its nature with any degree of certainty. I was not satisfied with merely collecting the bones that lay amongst the boulders, but had many of the stones turned over to see if bones lay under them. In no case, however, did I find a stone resting on any of the bones. Two of the larger boulders were quite too heavy to move; bones were found in cavities partly under these, in each case on the north side of the boulders. Near one of these boulders twenty-nine bones were found within a space of little more than four square feet. The general appearance which the bottom of the trench presented, when the remains of Megaceros were removed, reminded me of the rocky margin of a mountain tarn. It dipped slightly towards the west side, as shown in the accompanying sketch (fig. 1, *a*). Judging from the present appearance of the ground, the water of such a tarn could not have extended more than a few yards to the east; for on this side rises the southern base of the hill which forms the eastern side of the glen. I decided upon excavating the next trench further from the supposed margin of the tarn, and therefore at the west side of the drain. The point selected is marked *b* on the map (fig. 2). This trench was only eight feet square, but extended to a much greater depth than the first trench. At a depth of ten feet there was no sign of a stony bottom, although we had reached blue clay resembling that found between the boulders at the bottom of trench *a*. The blue clay was probed in every direction with a stout stick, which was easily forced into it to the extent of about 3 feet, but no hard substances were encountered. The only bone found was a solitary rib in the brown clay, about 6 feet from the surface. The position of the stratum in which this rib occurred is shown by vertical shading at *c*, fig. 1. Although this represents the section of a trench made subsequently, it illustrates equally well the section of trench *b*. This excavation was not sufficiently large to be worked with advantage, so it was abandoned, and another one commenced at a spot where I thought there would be less difficulty in reaching the bottom. The position of this trench is shown at *c*, fig. 2, and the section of it at *c*, fig. 1, where the various strata, corresponding with those encountered in the first cutting (*a*, fig. 1), are connected with them by straight lines. It will be observed, that the peat in trench *c* is nearly twice as deep as that in *a*; while the stratum of sand has thinned out to a mere trace. The next stratum in *c* is one that was not observed at all in *a*. It consists of a grey-coloured friable clay, containing layers of vegetable matter, often moss. This clay contained in some places numerous white specks, which turned blue on exposure. I found a few fragments as large as hazel-nuts. On analysis, this matter was found to consist almost entirely of ferrous phosphate, or Vivianite. The next stratum encountered in this trench consisted of brown clay, corresponding in appearance with that in which the bones were found in the first cutting. The only bones found in this, however, were two decayed fragments. The brown clay stratum was about 4 feet deep, and under it lay blue clay, like that which filled up the interspaces between the boulders in trench *a*. I cannot tell how far the blue clay extended. When the trench had reached the depth of 12 feet, we found a few small stones, two of granite and one of limestone; one of the granite stones was polished on one side. Although a pump was constantly at work, the water which leaked in from the sides of the trench gained on us rapidly; and it was evident that a greater depth could not be reached without considerable difficulty, so I was reluctantly compelled to abandon this trench.

The next excavation was made about 30 yards north of the first trench, and on the same side of the drain, but a little further from it (fig. 2, *d*). The section of this cutting closely resembled that of trench *a*. The peat was a little deeper, and contained a large log of wood in a horizontal position, probably a portion of the stem of a pine-tree of considerable size. At the north end the stony bottom was reached at a depth of only 4 feet; it dipped towards the southern end, where it was about 5 feet from the surface. The northern half of this trench did not contain a single fragment of bone or horn; the southern half was literally packed with them. The antlers were all very much broken, and fragments of horn were numerous; but the smaller bones of the skeleton were not as numerous here as in trench *a*. By continuing the excavation in a southerly direction, I should certainly have obtained a large number of heads, but there appeared to be little prospect of gaining additional information by such a course.

There can be little doubt that the trenches *a* and *d* occupy a position corresponding with the margin of the lake or tarn which once stretched along the bottom of the glen; while the trench *c*, where we failed to reach the bottom, and found no bones, must have been near the centre of the tarn. Judging from the general appearance of the surface, I concluded that the opposite margin of the supposed tarn must have been situated about the place marked *e*, fig. 2; and considering it important to learn if bones also abounded there, I decided upon exploring this part of the bog. A few yards to the west of this spot the ground suddenly rises several feet, and then, after a gentle slope of about 50 yards, there is another sudden rise, as we reach the high ground forming the southern end of the hill, which flanks the west side of the glen: the hill on the east side of the glen is not so high. In other respects the two sides are not dissimilar. As might be expected, the results of this cutting closely corresponded with those obtained in trench *a*. The strata passed through, however, were more conformable to those of trench *c*, the chief difference being in the thickness of each stratum, as may be seen from the section (*e*, fig. 1), which needs no further explanation. The stony bottom of this trench was so even and regular, that it presented the appearance of a pavement. It dipped towards the east about as much as the bottom of trench *a* did to the west. The remains found here were about the same in point of numbers as those of trench *a*, but they were in a very much worse state of preservation; indeed, several antlers were not removed, as it was found impossible to disturb them without breaking them into fragments. It was in this trench that most of the ribs and jaw-bones were found. At the southern end of it, a log of wood, about 4 feet long and 18 inches in diameter, was found, with one end resting on the stones, and the other close under the turf. This log was the only piece of wood found accompanying the bones in any of the cuttings. Its decayed condition rendered identification a matter of difficulty; it most resembled oak.

The next trench (fig. 2, *f*) was cut at the southern end of the first excavation, for the purpose of ascertaining how far the brown clay in which the bones were found extended towards the east. At the east end of this cutting the granite rock was reached, after passing through 3 feet of granite sand, no brown clay having been encountered. A little to the west of this spot a narrow tongue of brown clay protruded into the sand, dividing it about equally into an upper and a lower stratum. The lower stratum of sand thinned out towards the west, being replaced by the brown clay. About the spot where the lower stratum of granite sand disappeared, and the brown clay rested upon the stony bottom of the trench, several long bones were found between the granitic boulders. A little to the west of these bones we found a head, with large antlers, in a good state of preservation.

In none of these excavations did we find a true marl: the clays which have been referred to were almost entirely free from calcium carbonate, and had every appearance of a granitic origin. Not many yards north of the place where these clays were found, a light-coloured marl, rich in calcium carbonate, makes its appearance, almost immediately under the turf. A trench extending into this marl was opened at the north end of the glen (fig. 2, *g*), about 300 yards south of Ballybetagh House, and the same distance north of the other trenches. One end of this cutting was at the very base of the hill which flanks the east side of the glen. Here granite boulders were met with immediately under the surface, and as the excavation progressed, the bed of boulders was found to dip towards the west to about the same extent as the side of the adjoining hill. The turf varied from a few inches to about 3 feet in depth, and lay upon a stratum of fine granitic sand, traversed by occasional layers of coarse sand. Under the sand there was a stratum of brown clay, about 2 feet deep at the west end of the trench, and gradually thinning out towards the east end, where it became sandy in character. In the sandy part of this brown clay were found two fragments of bone, much decayed. Under the brown clay lay the marl, containing a large quantity of vegetable matter, but without any visible traces of shells. The marl, when examined microscopically, was found to abound in diatoms, in which respect it differed entirely from all the clays, as no diatoms could be detected in any of them. At a depth of 10 feet, the marl continued unaltered in character. The influx of water prevented the excavation from being conducted to a greater depth. It is noteworthy that the only fragment of bone which this trench yielded was found in a clay corresponding in appearance with that in which the bones were found at the other end of the glen. In the latter case, however, the brown clay lay upon granite boulders; while in the former case, the clay is separated from the boulders by a deep stratum of marl.

The remains found in the course of this exploration represent about fifty individuals of Cervus Megaceros. Taken in conjunction with those previously found here, we have a total of about eighty individuals of the great-horned deer, apparently all males, and one reindeer; and yet by far the greater part of this remarkable Pleistocene formation remains still unexplored.

Dr. Carte has examined the bones, and supplied the following list of them:—

List of the bones of Cervus Megaceros found in the cuttings made at Ballybetagh, during the month of August, 1875.

Thirty-six skulls, with antlers more or less broken, and many fragments of antlers.
Fifteen shed antlers, much mutilated.
Six Mandibular rami, representing three individuals.
Ten Atlas bones, perfect, and two broken.
Two Axes.
Six Cervical vertebræ.
Three Dorsal do.
One Lumbar do.
Two portions of Sternum.
Two fragments of Ilium, with glenoid cavity.
Thirteen ribs, nearly perfect, and a number of fragments.
Four Humeri, perfect, and three imperfect, representing six individuals, one very young.
Six Scapulæ, all more or less broken, representing five individuals.
Five Radii, and one imperfect.
Two Sacra, and one broken.
Four Femora, representing two individuals.
Three Tibiae, one broken, representing three individuals.
Five Metacarpals, representing four individuals.
Four Metatarsals.
One Os Calcis.
Two Astragali, representing two individuals.
Six Phalanges—three pes, and three manus, including an ungulate phalanx.
One Patella.
One Left Os Hyoides.

The majority of these bones belonged to youthful individuals.

XLVIII.—REPORT ON THE FLORA OF INISH-BOFIN, GALWAY. By A. G. MORE, F.L.S., M.R.I.A.

[Read April 24, 1876.]

HAVING received from the Academy a grant for the examination of the Flora of the West of Ireland, I paid, in August, 1875, a short visit to the remote Island of Bofin, feeling desirous to compare the vegetation of another Atlantic island belonging to a different geological formation with that of Aran, which latter has at various times attracted the notice of botanists, and of whose Flora a tolerably complete catalogue* has been lately published by my friend, Mr. H. C. Hart. An additional inducement to the choice of this locality was that Mr. M'Millan's recent discovery of the rare Helianthemum guttatum seemed to promise some chance that other rare plants might reward the exploration of Inish-Bofin, especially as this island has seldom been visited by any experienced botanist.

I was accompanied by my friend, Mr. R. M. Barrington, whose zealous co-operation I cannot too gratefully acknowledge, and whose untiring activity and botanical skill enabled me to accomplish much more than I could have done single-handed. We landed together on the afternoon of Sunday, the 15th of August, and left the island on the Friday following, having given one day to a cursory examination of the adjoining Island of Inish-Shark, which we found very unproductive in a botanical point of view, as we did not gather upon it a single plant not seen in Bofin. On Inish-Turk we landed for a few hours on our way to Westport, and gathered twenty species which we had not found in Bofin. We obtained excellent quarters and a most friendly reception in the house of the late Mr. M'Cormack, close to the Harbour of Inish-Bofin, and in all our excursions, we found a most trustworthy and intelligent companion in Sergeant O'Connor, of the Royal Irish Constabulary, whose name is already well known as the discoverer in Bofin of the gigantic cuttle-fish, Architeuthis dux, and who proved himself a most obliging and useful guide to all parts of the island. His local knowledge and influence, exerted on our behalf, in many ways facilitated our explorations.

The Island of Bofin, or in Irish, "Inis-Bo-finne," the Island of the White Cow—so called from the legend of a white cow which is traditionally reported to rise at uncertain intervals on the surface of the small lake named Bofin—lies in the Atlantic Ocean, off the junction of the two counties, Mayo and Galway, thirteen miles west from

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* "A list of plants found in the Islands of Aran, Galway Bay." By H. C. Hart: Dublin, 1875. See also another list, published by Professor E. P. Wright, in "Dublin Natural History Society Proceedings, 1866."

the entrance of the Killary Harbour, and about six miles from the nearest point of the mainland of Connemara. It is about 3½ miles long, and 2 miles wide at its greatest breadth, containing an area of 2312 acres (nearly four square miles), with a population of 663 inhabitants. Inish-Bofin was formerly attached to Mayo, but is now included in the county of Galway.

The geological formation belongs to the Lower Silurian Schists, with one narrow band of serpentine on the south-west, and a few trap-dykes at Royal Oak Cave, and at Bunnamullan Bay.

There is a fair extent of tillage, occupied by crops of potatoes, oats, barley, rye, &c., also of pasture-land; but the greater part of the surface consists of undulating, hilly moor, which rises at a few points to nearly 300 feet. There are four small lakes, and a few pools, together with a considerable extent of moist and boggy ground, producing a fair proportion of water-plants, sedges, rushes, &c. No trees occur; some alders and willows have been planted here and there, but the few stunted bushes of blackthorn and aspen, with several brambles, represent the entire arboreal vegetation.

The coast is almost everywhere bounded by rocky cliffs, with the exception of a small piece of low sand at the east end of the island, opposite Inish-Lyon, and some hillocks of blown sand to the south of the harbour, which, however, do not reach down to the shore itself.

The neighbouring island of Inish-Shark (581 acres) lies close to Inish-Bofin at less than a mile, and Inish-Turk (1445 acres) five miles to the north-east. Both these belong to the same Silurian formation, and were both visited by us, though we had not sufficient time to examine them thoroughly.

In the course of four days spent in Inish-Bofin, during which we were almost constantly at work, sometimes walking together, sometimes taking different beats, we gathered altogether more than 300 flowering plants and ferns, including several species eminently characteristic of the west coast, and some very rare or local in Ireland; and we succeeded in obtaining the desired materials for a very interesting contrast with Aran.

Inish-Bofin has seldom been visited by botanists. In August, 1801, Dr. Wade, then Professor of Botany to the Dublin Society, explored Galway under the auspices of the Society, and in the course of his tour landed in Bofin, where, in his report,* he records finding Arbutus uva-ursi (not seen by us), Artemisia absinthium (called "common wormwood" by Dr. Wade, and probably given by him instead of A. vulgaris), Empetrum nigrum, Juniperus communis, and Asplenium marinum—a short list, it must be confessed, and one which includes scarcely one of the most remarkable or characteristic plants.

Mr. W. M'Millan, one of the inspectors of National Schools, was

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* "Catalogus Plantarum Rariorum in Comitatu Gallovidiæ"—Dublin Society's Transactions, vol. ii., part 2, 1802.

more successful in 1872, when he discovered Helianthemum guttatum in its second Irish locality, and Euphorbia hiberna, in the neighbouring island of Inish-Turk.

Of the 303 plants collected by Mr. Barrington and myself, some of the most characteristic are the species which grow in water, or are attached to wet, heathy, or boggy localities, and such as I have usually observed upon a sandy or granitic soil; these will be sufficiently shown when we come to compare in detail the vegetation of Bofin with that of Aran.

If we follow Mr. H. C. Watson's method of grouping, we may place under the

ATLANTIC TYPE:

Saxifraga umbrosa.	Sedum anglicum. A.
Eriocaulon septangulare.	Crithmum maritimum. A.
† Senebiera didyma.	Pinguicula lusitanica.
Helianthemum guttatum.	Scirpus Savii. A.
Raphanus maritimus. A.	Lastræa æmula.

Only four of these have been observed in Aran.

NORTHERN TYPE:

Juniperus nana. A.	Pinguicula vulgaris.
Isoetes echinospora.	Empetrum nigrum.
Sagina subulata. A.?	Sparganium affine.
Lobelia Dortmanna.	Callitriche hamulata.

Of these last only one, or at most two, have been found in Aran.

Hence, we can see how in Inish-Bofin the western and northern elements are as strongly represented as in Aran, but by quite a different series of plants. The same mild and equable climate produces the same preponderance of the western and northern types, and while the different soil exhibits the same general results, the species themselves are different. In the main, the Flora of Inish-Bofin agrees fairly with that of the opposite coast of Mayo and Galway, although we miss Dabeocia polifolia, Vaccinium myrtillus, Viola Curtisii, Drosera anglica, Rhynchospora fusca, Utricularia intermedia, Juncus obtusiflorus, and a few other species which are common in Connemara.

That several of the ordinary "colonists" and other weeds should be wanting, is no more than might be expected in so remote a locality, cut off by the sea from constant communication with the mainland. No poppies, and few of the usual weeds of cultivation, infest the crops; but, at the same time, it is well worthy of remark that, judging from the circumstances of growth, and their restricted localities, many plants, elsewhere truly natives of Ireland, appear to have been introduced into Bofin.

In many species we noticed an unusual habit of growth, as in a large-flowered variety of Campanula rotundifolia, which my friend, Professor Babington, pronounces to be a singularly fine form, and the most remarkable which he has seen. Euphrasia officinalis, when on the exposed grassy slopes, grows with a dense spike of firm, fleshy leaves, and I have observed the same in Achill. Matricaria inodora, on the wild rocky ledges of the cliffs, offers a handsome flower as large as Chrysanthemum leucanthemum. On the tops of the gravelly hills, Erica tetralix, and Calluna vulgaris, grow close to the ground, with their leaves crowded on a few short branches. Erythræa centaurium scarcely raises its blossoms above the rosette of radical leaves. Agrostis pumila, and a very dwarf form of Plantago maritima, are abundant, and many other examples might be given of a stunted habit of growth.

The rarest plants gathered were:

Helianthemum guttatum.
Calamagrostis epigejos.
Elatine hexandra.
Eriocaulon septangulare.
Sparganium affine.
Isoetes echinospora.

Sixteen are hitherto unrecorded, as occurring in District VIII. of our "Cybele Hibernica," West Galway, and West Mayo, viz.:

† Fumaria pallidiflora.
‡ Sinapis nigra.
Polygala depressa.
Elatine hexandra.
Vicia angustifolia.
Rubus discolor.
R. thyrsoideus.
R. carpinifolius.
Rubus villicaulis.
† Arctium intermedium,
* Salix Smithiana.
Calamagrostis epigejos.
‡ Avena fatua.
‡ Lolium temulentum.
Glyceria plicata.
Isoetes echinospora.

When compared with that of Aran, which is typically a limestone Flora, the vegetation of Inish-Bofin presents a striking contrast, as will be best seen from the following list, which exhibits, side by side, the plants which have been found in one only of the two islands. The species most characteristic of each formation are printed in italics. The plants which are not certainly native are marked with the usual signs of *, certainly, ‡, probably, and †, possibly, introduced; and the few species which were gathered on Inish-Turk, though not in Bofin itself, are enclosed in brackets. I have ventured to append a mark of suspicion to some of the Aran plants whose nativity was left unchallenged by Mr. Hart, but whose conditions of growth or distribution are such as to give them the appearance of doubtful natives in Aran. The abbreviation "col." (colonist), indicates weeds found only in cultivated land, all of which are generally admitted to have been originally sown with the crops among which they now grow.

COMPARISON WITH ARAN.

PLANTS IN ARAN NOT FOUND IN BOFIN.	PLANTS IN BOFIN NOT FOUND IN ARAN.
Ranunculaceæ.	
Ranunculus heterophyllus. Ranunculus lingua ? ‡ *Aquilegia vulgaris.* *Thalictrum minus.*	Ranunculus Baudotii.
Nymphæaceæ.	
(*None in Aran.*)	*Nuphar luteum.*
Papaveraceæ.	
‡ Papaver dubium (col.) Glaucium luteum.	(*None in Bofin.*)
Fumariaceæ.	
‡ Fumaria officinalis (col.)	‡ Fumaria confusa (col.)
Cruciferæ.	
Crambe maritima. ‡ Thlaspi arvense (col. [Cochlearia officinalis.] Cardamine hirsuta. * Hesperis matronalis. Matthiola sinuata. Arabis ciliata. *A. hirsuta.* † Barbarea vulgaris. Nasturtium palustre. † Erysimum alliaria.	† Senebiera didyma. ‡ Brassica napus (col.) ‡ Sinapis arvensis.
Resedaceæ.	
Reseda luteola. ‡ *R. lutea.*	(*None in Bofin.*)
Cistaceæ.	
Helianthemum canum.	*Helianthemum guttatum.*
Violaceæ.	
Viola hirta. V. tricolor ? V. Curtisii.	*Viola canina* (*flavicornis*).

PLANTS IN ARAN NOT FOUND IN BOFIN.	PLANTS IN BOFIN NOT FOUND IN ARAN.
Droseraceæ.	
(*None in Aran.*)	*Drosera rotundifolia.*
Polygalaceæ.	
Polygala vulgaris.	*Polygala depressa.*
Elatinaceæ.	
(*None in Aran.*)	*Elatine hexandra.*
Caryophyllaceæ.	
‡ Silene inflata (col.) Sagina apetala. S. maritima. Spergularia marina. *Alsine verna.* *Cerastium arvense.*	*Lychnis flos-cuculi.* *Sagina subulata.** ‡ *Spergula arvensis* (col.) Spergularia salina. Cerastium tetrandrum.
Linaceæ.	
	Radiola millegrana.
Malvaceæ.	
† Lavatera arborea.	
Hypericaceæ.	
	Hypericum elodes.
Geraniaceæ.	
Geranium lucidum. *G. sanguineum.* † Erodium moschatum.	
Oxalidaceæ.	
(*None in Aran.*)	Oxalis acetosella.
Celastraceæ.	
Euonymus europæus.	(*None in Bofin.*)

* *Sagina stricta* (*maritima*), and not *S. subulata*, was the plant gathered by Professor Oliver near Kilronan, and this misquotation of ours, in the "Cybele Hibernica," seems to have misled later observers; as I have always found *S. subulata* decidedly attached to a sandy or granitic subsoil.

PLANTS IN ARAN NOT FOUND IN BOFIN.	PLANTS IN BOFIN NOT FOUND IN ARAN.
Rhamnaceæ.	
Rhamnus catharticus.	(*None in Bofin.*)
Leguminosæ.	
Ulex nanus ? † Medicago lupulina. Trifolium procumbens. [†T. . . . arvense]. Lotus major. *Astragalus hypoglottis.*	Vicia angustifolia.
Rosaceæ.	
Geum urbanum. Fragaria vesca. *Rubus saxatilis.* *R. cæsius.* *Poterium sanguisorba.* Alchemilla vulgaris. † A. arvensis. † Cratægus oxyacantha.	*Comarum palustre.* Rubus discolor. R. thyrsoideus. R. carpinifolius. R. villicaulis.
Onagraceæ.	
Epilobium hirsutum. Circæa lutetiana.	*Epilobium palustre.*
Haloragaceæ.	
Hippuris vulgaris.	*Callitriche hamulata.*
Lythraceæ.	
	Peplis portula.
Portulaceæ.	
	Montia fontana.
Crassulaceæ.	
[Sedum rhodiola]. Cotyledon umbilicus.	
Saxifragaceæ.	
Saxifraga hypnoides. *S. tridactylites.*	*Saxifraga umbrosa.*

Plants in Aran not found in Bofin.	Plants in Bofin not found in Aran.
Umbelliferæ.	
Sanicula europæa. Eryngium maritimum. * Smyrnium olusatrum. ‡ Apium graveolens. Helosciadium nodiflorum. *Pimpinella magna.* ‡ Æthusa cynapium (col.) Haloscias scoticum ? * *Pastinaca sativa.* Torilis anthriscus. † *T. nodosa.* [Anthriscus sylvestris]. † *A. vulgaris.*	(Bofin is very poor in Umbelliferæ.)
Cornaceæ.	
Cornus sanguinea.	
Caprifoliaceæ.	
‡ Sambucus ebulus. Viburnum opulus.	
Rubiaceæ.	
Rubia peregrina. *Galium sylvestre.* *G. boreale.* ‡ Sherardia arvensis (col.) *Asperula cynanchica.*	*Galium saxatile.*
Valerianaceæ.	
Valeriana officinalis. ‡ Valerianella olitoria (col.)	
Compositæ.	
Crepis virens. Hieracium anglicum. *Carduus nutans.* * Carduus Marianus. C. tenuiflorus. Carlina vulgaris. *Eupatorium cannabinum.* * Artemisia absinthium. Antennaria dioica. Filago germanica. Tanacetum vulgare.	Thrincia hirta. Carduus palustris. *Senecio sylvaticus.*

PLANTS IN ARAN NOT FOUND IN BOFIN.	PLANTS IN BOFIN NOT FOUND IN ARAN.
Campanulaceæ.	
	Jasione montana. *Lobelia Dortmanna.*
Ericaceæ.	
	Erica tetralix.
Aquifoliaceæ.	
[Ilex aquifolium].	
Oleineæ.	
‡ Fraxinus excelsior.	
Gentianaceæ.	
Gentiana verna. *Chlora perfoliata.*	
Convolvulaceæ.	
Convolvulus soldanella. † C. arvensis (col ?).	
Solanaceæ.	
Solanum dulcamara.	(*None in Bofin.*)
Scrophulariaceæ.	
Scrophularia nodosa. † *Verbascum thapsus.* Veronica serpyllifolia. V. officinalis. ‡ V. hederifolia (col.)	Scrophularia aquatica. Pedicularis palustris. ‡ Veronica polita (col.)
Orobanchaceæ.	
Orobanche hederæ.	(*None in Bofin.*)
Labiatæ.	
Lycopus europæus. † Mentha arvensis (col.) † *Calamintha officinalis.* Ajuga pyramidalis. Ajuga reptans. Stachys sylvatica. Nepeta glechoma. ‡ Marrubium vulgare.	*Scutellaria minor.*

Plants in Aran not found in Bofin.	Plants in Bofin not found in Aran.
Boraginaceæ.	
Myosotis palustris. M. versicolor. *Lithospermum officinale.* ‡ Symphytum officinale.	Myosotis cæspitosa.
Pinguiculaceæ.	
(*None in Aran.*)	*Pinguicula vulgaris.* *P. lusitanica.* *Utricularia minor.*
Primulaceæ.	
[Lysimachia nemorum].	*Centunculus minimus.*
Plumbaginaceæ.	
Statice occidentalis.	
Chenopodiaceæ.	
Atriplex littoralis? Beta maritima. Suæda maritima. Salicornia herbacea.	Atriplex Babingtonii.
Polygonaceæ.	
Rumex conglomeratus. Polygonum Raii.	† Rumex crispus.
Empetraceæ.	
	Empetrum nigrum.
Euphorbiaceæ.	
‡ Euphorbia peplus (col.) E. paralias. E. portlandica.	
Urticaceæ.	
* Humulus lupulus. *Parietaria officinalis.*	
Amentiferæ.	
Quercus robur. [Corylus avellana]. * Populus alba (planted). Salix caprea.	Populus tremula. * Salix Smithiana. *S. aurita.* *Myrica gale.*

PLANTS IN ARAN NOT FOUND IN BOFIN.	PLANTS IN BOFIN NOT FOUND IN ARAN.
Orchidaceæ.	
Spiranthes autumnalis.	Orchis maculata.
Orchis mascula.	
O. pyramidalis.	
O. conopsea.	
Habenaria viridis.	
Amaryllidaceæ.	
* Narcissus biflorus.	
Liliaceæ.	
	Narthecium ossifragum.
Alismaceæ.	
Alisma ranunculoides.	
Triglochin maritimum.	
Naiadaceæ.	
	Potamogeton pusillus.
	P. polygonifolius.
Typhaceæ.	
	Sparganium affine.
Araceæ.	
Arum maculatum.	
Restiaceæ.	
	Eriocaulon septangulare.
Juncaceæ.	
	Juncus lamprocarpus.
	J. supinus.
	J. compressus.
	J. squarrosus.
Luzula campestris.	*Luzula multiflora.*

Plants in Aran not found in Bofin.	Plants in Bofin not found in Aran.
	Cyperaceæ.
[Scirpus lacustris].	*Rhynchospora alba.*
S. setaceus.	Eleocharis palustris.
S. maritimus.	*E. multicaulis.*
	Scirpus fluitans.
	Eriophorum angustifolium.
[Carex vulpina].	Carex pulicaris.
	C. stellulata.
	C. extensa.
	C. binervis.
	C. panicea.
	C. præcox.
	C. ampullacea.
	Gramineæ.
‡ Phleum pratense.	*Aira flexuosa.*
P. arenarium.	‡ Avena fatua (col.)
Alopecurus geniculatus.	Triodia decumbens.
Sesleria cærulea.	Koeleria cristata.
[Aira cæspitosa].	Poa trivialis.
Sclerochloa maritima.	Festuca sciuroides.
S. rigida.	F. elatior.
	‡ Lolium temulentum (col.)
	Nardus stricta.
	Filices.
Ceterach officinarum.	Lastræa filix-mas.
Polystichum angulare.	*L. æmula.*
Asplenium trichomanes.	*Athyrium filix-fœmina.*
Scolopendrium vulgare.	*Osmunda regalis.*
Adiantum capillus-Veneris.	
	Lycopodiaceæ.
	Isoetes echinospora.
	Equisetaceæ.
Equisetum hyemale?	Equisetum arvense.
	E. limosum.

This gives 161 plants peculiar to Aran; 92 to Bofin; but if we deduct the naturalized plants on both sides, we have about 120 for Aran, and 80 for Bofin.

From the above it will be easily seen that each formation has its own peculiar plants. Aran, which consists solely of carboniferous limestone, shows in a remarkable degree both the predominance of lime-loving plants, and also the greater variety of species which is usually observed upon calcareous soils. Bofin exhibits, as clearly, a series of plants which prefer schistose, granitic or siliceous soils; indeed, the only two lime-loving species which I observed in Inish-Bofin were Sinapis alba (an introduced weed), and Asplenium ruta-muraria, which grows upon the walls of the ruined church of St. Coleman.

The only scarce plants common to Aran and Bofin are Calamagrostis epigejos, a true native, and Allium Babingtonii, a leek which was, no doubt, formerly cultivated in many parts of the west of Ireland, as well as in Cornwall.

The three Aran Isles, with a much larger area than Inish-Bofin, and with a greater extent of coast line, sea-sands, and muddy shore, have hitherto yielded 372 species, to which we may, perhaps, safely add about 40 more, which will give an estimated total of 410 for the whole Aran group. Inish-Bofin itself reckons 303, or with Inish-Turk, 323, and in the silurian group of Inish-Bofin, Inish-Shark, and Inish-Turk, it is probable that the whole number does not exceed 350.

With further exploration, the plants now apparently peculiar to each group will, no doubt, be considerably reduced, so that instead of 221 species common to both, these will probably be found to be nearly 300, leaving about 50 plants peculiar to the three Isles of Bofin, Shark, and Turk, and about 100 to the Aran group.

This is, indeed, a very striking difference between the floras of two groups of islands, situated under the same conditions of climate, and separated by a distance of only thirty-five miles, and shows very plainly how much the vegetation is influenced by the nature of the subsoil.

LIST OF THE PLANTS FOUND IN INISH-BOFIN.

RANUNCULACEÆ.

Ranunculus Baudotii, Godron.—In Church Lake, and in the small lake called Lough-na-brand, on the sand-hills south of the harbour.

R. trichophyllus, Chaix.

R. hederaceus, Linn.—In many places, but we did not observe *R. Lenormandi*.

R. flammula, Linn.—Also var. *pseudo-reptans*, Syme.

R. acris, Linn.—(*tomophyllus*, Jordan).—Frequent.

R. repens, Linn.

R. bulbosus, Linn.—On the sand-hills south of the harbour.

NYMPHÆACEÆ.

Nuphar luteum, Sm.—Plentiful in Church Lake.

FUMARIACEÆ.

‡ *Fumaria pallidiflora*, Jord.—Cultivated ground near St. Coleman's Church or Abbey.
‡ *F. confusa*, Jord.—In several places, a colonist.

CRUCIFERÆ.

Cakile maritima, Scop.—On the sands opposite Inish-Lyon.
† *Senebiera coronopus*, Poir.—Common about the harbour, but always near houses, as if introduced.
‡ *S. didyma*, Sm.—In several places along the road side, and among rubbish near the harbour.
† *Capsella bursa-pastoris*, D.C.—Waste places and a weed in gardens, probably introduced.
Cochlearia danica, Linn.—Rare.
Cardamine pratensis, Linn.—Common.
Nasturtium officinale, Br.
† *Sisymbrium officinale*, Scop.—Chiefly about houses.
‡ *Brassica napus*, Linn.—A colonist in cultivated land.
‡ *Sinapis arvensis*, Linn.
‡ *S. alba*, Linn.
‡ *S. nigra*.
‡ *Raphanus raphanistrum*, Linn.
} All four colonists in cultivated ground, or borders of fields.
R. maritimus, Sm.—On the sands opposite Inish-Lyon, and a few plants near the harbour.

CISTACEÆ.

Helianthemum guttatum, Mill (var. *Breweri*, Planch).—Plentiful in many places, especially on high ground, both in Bofin and Shark, but we did not observe it on Inish-Turk.

VIOLACEÆ.

Viola palustris, Linn.—Frequent.
V. sylvatica, Fries.—Shady banks.
V. canina, Linn. (*flavicornis*, Sm.).—Stony or heathy margins of the lakes in several places.

DROSERACEÆ.

Drosera rotundifolia, Linn.—Frequent.

POLYGALACEÆ.

Polygala depressa, Wender.—This was the only form found, well marked by the crowded oval leaves.

ELATINACEÆ.

Elatine hexandra, D.C.—In shallow water on the gravelly bottom of Lough Gowlanagower, Lough-na-grooaun, and Lough Fawna, abundantly.

CARYOPHYLLACEÆ.

Silene maritima, With.—Not common.
Lychnis flos-cuculi, Linn.—Only near Church Lake.
Honckenya peploides, Epr.—Sands opposite Inish-Lyon.
Sagina procumbens, Linn.
S. subulata, Wimm.—In one place only, at south side of the island.
S. nodosa, Mey.—Damp rocky ledges near St. Coleman's Church or Abbey.
‡ *Spergula arvensis*, Linn.—A weed in cultivated land. Both forms, *S. arvensis* (Reich.) and *S. vulgaris* (Boënng.), occurred, and most of the specimens which we examined belonged to the former.
Spergularia rupicola, Lebel.—About the cliffs at west end of Bofin, in many places.
S. salina, Prest.—On damp ground at foot of the cliffs in south-west of the island.
Arenaria serpyllifolia, Linn.—Typical form only.
Stellaria media, With.
Cerastium glomeratum, Thuill. }
C. triviale, Link. } All three frequent.
C. tetrandrum, Curt. }

LINACEÆ.

Linum catharticum, Linn.—In many places.
Radiola millegrana, Sm.—Plentiful.

MALVACEÆ.

† *Malva sylvestris*, Linn.—Near the harbour and about the village. A variety with leaves deeply angulated and their base wedge-shaped, instead of cordate, was gathered.

HYPERICACEÆ.

Hypericum androsæmum, Linn.—On rocks near Church Lake.
H. quadrangulum (*tetrapterum*, Fries).—Frequent.
H. humifusum, Linn.
H. pulchrum, Linn.
H. elodes, Linn.

Geraniaceæ.

Erodium cicutarium, Sm.—Shady places, frequent.
Geranium molle, Linn.—Rocks near Church Lake.
† *G. dissectum*, Linn.—Waste and cultivated ground, rare.
G. Robertianum, Linn.
var. *purpureum*, Forst.—On heaps of stones near the old ruin of St. Coleman's Church.

Oxalidaceæ.

Oxalis acetosella, Linn.—Near Church Lake.

Leguminosæ.

Anthyllis vulneraria, Linn.
† *Trifolium repens*, Linn. }
† *T. pratense*, Linn. } All three probably introduced.
† *T. minus*, Relh. }
Lotus corniculatus, Linn.—In many places.
Vicia cracca, Linn.
V. sativa. Var. ‡ *segetalis*, Thuil.—In stubbles and along hedges or borders of fields, probably the remains of former cultivation.
V. angustifolia, Roth.—Sandy ground, eastward of the village.
V. sepium, Linn.—Shady banks and bushy places.
Lathyrus pratensis, Linn.—Shores of harbour.

Rosaceæ.

Prunus spinosa, Linn.—Grassy banks on the east side of the harbour, very sparingly.
Spiræa ulmaria, Linn.
Potentilla anserina, Linn.
P. reptans, Linn.—Rather rare.
P. tormentilla, Linn.—Both typical, and also the variety or hybrid, *P. procumbens*, Sibth.
Comarum palustre, Linn.
Rubus discolor, W. et N.
R. thyrsoideus, Wimm.
R. carpinifolius, W. et N.
R. villicaulis, W. et N.

These four brambles were all gathered on the east side of the village and about Church Lake. I am much indebted to my kind friend Professor C. C. Babington, who was good enough to take the trouble to examine the specimens which I collected, and who has thus approximately determined their names, though from their incompleteness the specimens were not quite sufficient for certainty.

Rosa spinosissima, Linn.—In several places.

R. canina, Linn.—Rare; east side of the harbour only.
†*Agrimonia eupatoria*, Linn.—Rare; roadside towards Church Lake. (R. M. B.)

ONAGRACEÆ.

Epilobium parviflorum, Schreb.
E. montanum, Linn.
E. palustre, Linn.
} All three frequent.

E. tetragonum, Linn.—Only the form *obscurum*, Schreb.

HALORAGACEÆ.

Myriophyllum alterniflorum, D. C.—Frequent.
Callitriche verna, Linn.
C. platycarpa, Kutz.—On muddy borders of streams.
C. hamulata, Kutz.—Frequent, and a plant very characteristic of mountain lakes. A small form, with very narrow leaves, grows in Lough Gowlanagower.

LYTHRACEÆ.

Lythrum salicaria, Linn.—In many places.
Peplis portula, Linn.—Frequent.

PORTULACEÆ.

Montia fontana, Linn.—Common.

CRASSULACEÆ.

Sedum anglicum, Linn.—Frequent, and of very large size, on stone fences round the harbour.
S. acre, Linn.

SAXIFRAGACEÆ.

S. umbrosa, Linn.—On the rocks south of Church Lake, and found also on Inish-Turk. As in Achill, and I believe throughout Connemara, the prevailing, if not the only, form is *serratifolia*. Our guide in Inish-Turk called it the "Leaf" (not Cabbage) "of St. Patrick."

ARALIACEÆ.

Hedera helix, Linn.—Frequent on the cliffs, &c.

UMBELLIFERÆ.

Hydrocotyle vulgaris, Linn.—Plentiful.
‡ *Conium maculatum*, Linn.—About the harbour and near houses along roadsides, on rubbish, probably introduced.

Helosciadium inundatum, Koch.—In several places, and found also in Inish-Shark.

Crithmum maritimum, Linn.—Plentiful along the south-west shore.

Angelica sylvestris, Linn.—On damp ledges of the cliffs; also in Inish-Turk, where it is fully exposed to the Atlantic gales.

‡ *Heracleum sphondylium*, Linn.—Observed only on the grassy lawn of Mr. M'Cormack's garden, where it was, in all probability, sown unintentionally.

Daucus carota, Linn.—Rocks, banks, and pastures; frequent.

CAPRIFOLIACEÆ.

* *Sambucus nigra*, Linn.—A few shrubs only, and evidently planted, near some cottages in the centre of the island.

Lonicera periclymenum, Linn.—About Church Lake, &c.

RUBIACEÆ.

Galium verum, Linn.

G. palustre, Linn.—Chiefly as the most usual form called *G. Witheringii*, but a few robust plants in the marshy borders of Church Lake are nearer to *G. elongatum*, Presl.

G. saxatile, Linn.—In many places, and a very characteristic species.

* *G. aparine*, Linn.—Only in and about cultivated land, no doubt introduced.

DIPSACACEÆ.

Scabiosa succisa, Linn.

COMPOSITÆ.

Thrincia hirta, Roth.

Oporinia autumnalis, Don.

Hypochæris radicata, Linn.

‡ *Sonchus arvensis*, Linn.—A colonist among the crops.

† *S. asper*, Hoffm.
† *S. oleraceus*, Linn. } Both possibly introduced.

Hieracium pilosella, Linn.—Near St. Coleman's Church.

† *Taraxacum officinale*, Wigg.—Perhaps introduced.

‡ *Lapsana communis*, Linn.—A colonist.

† *Arctium lappa* (*intermedium*, Lange).—This was, as in other parts of Ireland, the only form seen.

† *Carduus lanceolatus*, Linn.

C. palustris, Linn.

† *C. arvensis*, Curt.—Rather rare, and perhaps introduced.

Centaurea nigra, Linn.

† *S. scabiosa*, Linn.—Only on the sand-hills among the rabbit burrows, and perhaps introduced.

‡ *Artemisia vulgaris*, Linn.—Borders of fields, waste places, and in cultivated land. Now apparently a colonist, whatever its origin. *A. absinthium* was not observed, and probably Dr. Wade entered the wrong species in his list.

Gnaphalium uliginosum, Linn.
Tussilago farfara, Linn.
Aster tripolium, Linn.—On the south-west shore.
Solidago virgaurea, Linn.
† *Senecio vulgaris*, Linn.—Perhaps introduced.
S. sylvaticus, Linn.
S. Jacobæa, Linn.—On the sand-hills south of the harbour we found a variety with the ligulate florets much broader and shorter than usual, giving the flower an appearance something like a Cineraria. The rayless form did not occur.
S. aquaticus, Huds.
Inula dysenterica, Linn.—Near St. Coleman's Church.
† *Bellis perennis*, Linn.—Possibly introduced.
‡ *Chrysanthemum segetum*, Linn.—A weed in the crops.
C. leucanthemum, Linn.—Rare.
Matricaria inodora, Linn.—A fine variety, with large and conspicuous flowers; grows on rocky ledges of the cliffs, both in Bofin and in Achill.
Achillea ptarmica, Linn.
A. millefolium, Linn.

CAMPANULACEÆ.

Campanula rotundifolia, Linn.; var. *speciosa*.—A large-flowered and very handsome variety grows among the rabbit burrows south of the harbour. The stems are from nine to twenty inches high, the leaves broader and more crowded than usual, lanceolate and linear-lanceolate on the middle of the stem. Flowers from one to twelve, with a corolla at least an inch long. This plant, in some of its characters, comes near to the variety *arctica*, figured in "Flora Danica," XVI., Tab. 2711, but has much larger flowers. It also agrees to some extent with a var. *lancifolia*, described in Hartman's "Skandinaviens Flora," but the stem is not recumbent. Being apparently distinct from any described variety, I believe this beautiful plant quite deserves a separate name, as var. *speciosa*, which I here propose for it.
Jasione montana, Linn.—Plentiful, and one of the most characteristic species.
Lobelia Dortmanna, Linn.—Plentiful in Lough-na-grooaun; very rare in Lough Gowlanagower.

ERICACEÆ.

Erica tetralix, Linn.—Common even on the tops of the barren stony hills, where it assumes a dwarf, stunted habit, offering only two or three branches, on which the leaves are densely crowded.
E. cinerea, Linn.—Plentiful.
Calluna vulgaris, Salisb.—In exposed stony places it occurs quite stunted, and with leaves crowded in the same way as in *E. tetralix*.

Gentianaceæ.

Gentiana campestris, Linn.—Frequent, and of large size. A variety with white flowers also occurred.

Erythræa centaurium, Pers.—Chiefly in the form with broad radical leaves, and little or no stem, which has often been miscalled "*E. littoralis.*"

Menyanthes trifoliata, Linn.—Church Lake.

Convolvulaceæ.

Convolvulus sepium, Linn.—Frequent in bushy places and on fences, and nearly always with pink flowers.

Scrophulariaceæ.

Veronica arvensis, Linn.

V. anagallis, Linn.—Streamside near St. Coleman's Church.

V. beccabungæ, Linn.

V. chamædrys, Linn.

† *V. agrestis*, Linn. } Cultivated land and roadsides; probably introduced.
† *V. polita*, Fries. }

† *Bartsia odontites*, Huds.—All the plants which we observed belonged to the form *E. serotina*, Reich; perhaps a colonist only.

Euphrasia officinalis, Linn.—Both the typical form and *E. gracilis*, Fries, the latter rather more frequent of the two. Also a maritime variety with stiff fleshy broad leaves, and bracts closely crowded; a form which I have also noticed in Achill.

Rhinanthus crista-galli, Linn.

Pedicularis palustris, Linn.—Rare, near Church Lake.

P. sylvatica, Linn.—Frequent.

Scrophularia aquatica, Linn.—Rare, observed in one place only, east of the village.

Labiatæ.

Mentha aquatica, Linn.—Frequent.

Thymus serpyllum, Linn.

Teucrium scorodonia, Linn.

‡ *Lamium purpureum*, Linn.—A weed in gardens, etc.

† *Galeopsis tetrahit*, Linn.—On rubbish, and in borders of fields about the village, probably introduced.

Stachys palustris, Linn.

‡ *S. arvensis*, Linn.—Cultivated ground, a colonist.

Prunella vulgaris, Linn.

Scutellaria minor, Linn.—Near Church Lake.

BORAGINACEÆ.

Myosotis cæspitosa, Schultz.—Frequent.
M. arvensis, Hoffm.

PINGUICULACEÆ.

Pinguicula vulgaris, Linn.—Frequent.
P. lusitanica, Linn.—Rather rare.
Utricularia minor, Linn.—At west end of the island, in one place only.

PRIMULACEÆ.

Primula vulgaris, Huds.—Near Church Lake; a few plants flowering so late as August 19th.
‡ *Anagallis arvensis*, Linn.—A colonist probably.
A. tenella, Linn.
Centunculus minimus, Linn.—Not common, but found at both east and west ends of the island.
Samolus Valerandi, Linn.—Frequent.
Glaux maritima, Linn.

PLUMBAGINACEÆ.

Armeria maritima, Willd.—Frequent.

PLANTAGINACEÆ.

† *Plantago major*, Linn.—About Church Lake, &c.; not common, and probably introduced.
† *P. lanceolata*, Linn.—Perhaps introduced.
P. maritima, Linn.—Common, and a dwarf form is abundant all over the tops of the hills.
P. coronopus, Linn.—Frequent.
Littorella lacustris, Linn.—Borders of Lough Fawna, &c.

CHENOPODIACEÆ.

‡ *Chenopodium album*, Linn.—Both varieties: *C. candicans*, Linn; and *C. viride*, Linn.
Atriplex Babingtonii, Woods.—Common about the harbour, &c.
A. patula, Linn.—The vars. *angustifolia* and †*erecta* were both frequent. The last occurs only in cultivated ground, as if a colonist.
Salsola Kali, Linn.—Sands opposite Inish-Lyon.

POLYGONACEÆ.

Polygonum amphibium, Linn.—In the small lake in the sand-hills, called Lough-na-brand, and here the terrestrial form was flowering freely.

P. persicaria, Linn.
P. hydropiper, Linn. } All three frequent.
P. aviculare, Linn.

† *P. convolvulus*, Linn.—A weed in cultivated land and borders of fields.

† *Rumex crispus*, Linn.—Frequent, but perhaps not native.

† *R. obtusifolius*, Linn.—Like the former, perhaps introduced.

R. acetosa, Linn.—Not uncommon.

R. acetosella, Linn.—Ditto.

Obs.—We could not find *R. sanguineus* nor *R. conglomeratus*.

Empetraceæ.

Empetrum nigrum, Linn.—Very rare; observed only in one place near a blowhole west of Moylanboy Bay (R. M. B.) Also on Inish-Turk.

Euphorbiaceæ.

‡ *Euphorbia helioscopia*, Linn.—Among crops; rare.

Urticaceæ.

* *Urtica urens*, Linn.
* *U. dioica*, Linn. } Waysides and waste places; both no doubt introduced.

Amentiferæ.

Populus tremula, Linn.—Sparingly on rocky banks at east end of the harbour. Also on Inish-Turk.

* *Salix viminalis*, Linn.
* *S. Smithiana*, Willd. } Both introduced.

S. aurita, Linn.—The only sallow observed.

S. repens, Linn.—Frequent.

Myrica Gale, Linn.—Plentiful in one locality only, near Bunnamullen Bay. (R. M. B.)

Coniferæ.

Juniperus communis, Linn.—Only the form or variety, *J. nana*, Willd.

Orchidaceæ.

Orchis maculata, Linn.—Rather rare, near Church Lake.

Iridaceæ.

Iris pseudacorus, Linn.—Near Church Lake, &c.

LILIACEÆ.

* *Allium Babingtonii*, Borr.—Among the ruins of a deserted cottage, east of the harbour (R. M. B.) Also in a garden enclosure close to a cottage, to the south of Lough Gowlanagower; several of the heads viviparous. This is, no doubt, a relic of former cultivation, as it appears also to be in all the other localities, wherever I have seen it in the West of Ireland. At Roundstone it occurs only along the borders of garden enclosures. On the south side of Clew Bay, and near Menlough, Galway, always about the ruins of cottages or deserted gardens.

Narthecium ossifragum, Huds.—At west end of the island.

ALISMACEÆ.

Triglochin palustre, Linn.—Along the south-west shore.

NAIADACEÆ.

Potamogeton pectinatus, Linn.—North end of Lough Bofin.

P. pusillus, Linn.—In Church Lake.

P. natans, Linn.—Very fine and plentiful on Lough-na-grooaun.

P. polygonifolius, Pourr.—Common in damp boggy places.

Zostera marina, Linn.—In the harbour.

LEMNACEÆ.

Lemna minor, Linn.—Frequent in pools and slow streams.

TYPHACEÆ.

Sparganium affine, Schn.—Plentiful in Lough Gowlanagower and Lough-na-grooaun.

RESTIACEÆ.

Eriocaulon septangulare, With.—Several large patches along the west side of Lough-na-grooaun.

JUNCACEÆ.

Juncus communis, Mey.—Both forms, *conglomeratus* and *effusus*, were observed.

J. acutiflorus, Ehrh.—Frequent.

J. lamprocarpus, Ehrh.—Frequent.

J. supinus, Moench.—Plentiful, and the submerged variety, with setaceous leaves, is abundant in most of the lakes.

J. compressus, Jacq.; var. *Gerardi*, Lois.—Along the south-west shore.

J. bufonius, Linn.—Common.
J. squarrosus, Linn.—Hilly ground at west end of the island.
Luzula multiflora, Lej.—*L. campestris* was not seen.

Cyperaceæ.

Schœnus nigricans, Linn.—Above Bunnamullen Bay, with *Myrica* (R. M. B.) Also on Inish-Turk.
Rhynchospora alba, Vahl.—Rare. At Bunnamullen Bay, and at west end of Bofin.
Scirpus Savii, S. et M.—Frequent.
S. fluitans, Linn.—Frequent, and a very characteristic species.
Eleocharis palustris, Br.—Church Lake, &c.
E. multicaulis, Sm.—Plentiful and characteristic.
Eriophorum angustifolium, Roth.—Frequent.
Carex pulicaris, Linn.—Near Church Lake, &c.
C. stellulata, Good.—Abundant.
C. arenaria, Linn.
C. flava, var. *lepidocarpa*, Tausch.—Common.
C. extensa, Good.—South-west shore.
C. distans, Linn.—South-west shore.
C. binervis, Sm.—West end of the island.
C. panicea, Linn.—Frequent.
C. glauca, Scop.—Common.
C. præcox, Jacq.
C. ampullacea, Good.—Church Lake.

Gramineæ.

Anthoxanthum odoratum, Linn.
Agrostis canina, Linn.
A. vulgaris, With.
var. *pumila*, Lightf.—Frequent on the higher parts of the hills.
A. alba, Linn.—Common, with many varieties.
Psamma arenaria, R. et S.
Phragmites communis, Trin.
Calamagrostis epigejos, Roth.—Sparingly on rocky banks at east end of the inner harbour. It is curious to find both in Bofin and Aran, two isolated localities, for a grass which is so rare in Ireland.
Aira flexuosa, Linn.
A. caryophyllea, Linn.
A. præcox, Linn.
‡ *Avena fatua*, Linn.—A weed in the corn crops of Bofin and Inish-Shark.
† *Arrhenatherum avenaceum*, Beauv.—Perhaps introduced, but now an abundant weed.
Holcus lanatus, Linn.

Triodia decumbens, Beauv.
Koeleria cristata, Pers.—Banks opposite Inish-Lyon, &c.
Molinia cærulea, Moench.
Glyceria fluitans, Br.—Common.
G. plicata, Fries.—Rare; in one place only.
Sclerochloa loliacea, Woods.
Poa annua, Linn.
P. pratensis, Linn.
† *P. trivialis*, Linn.—Possibly introduced.
Cynosurus cristatus, Linn.
Dactylis glomerata, Linn.
† *Festuca sciuroides*, Roth.—Very rare on banks, and probably not native.
F. ovina, Linn.
F. duriuscula, Linn.
F. rubra, var. *sabulicola*, Duf.
F. elatior, Linn.—Also on Inish-Turk.
F. pratensis, Huds.
Bromus mollis, Linn.
var. *subglaber*, Sands.—On the sea-shore.
Brachypodium sylvaticum, Beauv.—East of harbour, &c.
Triticum repens, Linn.
T. junceum, Linn.—Sands opposite Inish-Lyon.
Lolium perenne, Linn.
‡ *L. temulentum*, Linn.—A weed among corn.
Nardus stricta, Linn.—Frequent.

FILICES.

Polypodium vulgare, Linn. }
Lastræa filix-mas, Presl. } Frequent.
L. dilatata, Presl. }
L. æmula, Brack.—Rare, only near Lough Fawna (R.M.B.) On the west side of Inish-Turk (A.G.M.)
Athyrium filix-fœmina, Roth.—Frequent. A variety found among the rocks near Church Lake has a frond broader than usual, with wide ovate pinnules, resembling those of *Lastræa dilatata*.
Asplenium marinum, Linn.—Abundant in many parts of the cliffs.
A. adiantum-nigrum, Linn.—In its typical form, and no plants approaching *A. acutum*, Bory.
A. ruta-muraria, Linn.—On the ruins of St. Coleman's Church.
Blechnum boreale, Sw.—Not uncommon.
Pteris aquilina, Linn.
Osmunda regalis, Linn.—Frequent.

LYCOPODIACEÆ.

Isoetes echinospora, Dur.—In Lough Gowla-na-gower and Lough-na-grooaun.

EQUISETACEÆ.

Equisetum arvense, Linn.
E. limosum, Linn.

To these should be added 20 other plants gathered by us on Inish-Turk, an island belonging to the same silurian formation, and which lies five miles north of Inish-Bofin. Those found in Aran are marked A.

Cochlearia officinalis. A.
Lychnis diurna.
† *Trifolium arvense.* A.
Orobus tuberosus.
Sedum rhodiola. A.
Œnanthe crocata.
Anthriscus sylvestris. A.
Ilex aquifolium. A.
Lysimachia nemorum. A.
Euphorbia hyberna.
Corylus avellana. A.
Betula alba.
Salix cinerea.
Scirpus lacustris. A.
Carex dioica.
C. vulpina. A.
C. paniculata.
C. vulgaris.
Aira cæspitosa. A.
Orchis incarnata ?

This will make a total of 323 species on the three Islands of Inish-Bofin, Inish-Shark, and Inish-Turk—a number which further investigation will probably raise to 350.

XLIX.—On a New Chemical Test for Alcohol. By Edmund W. Davy, A.M., M.D., Professor of Forensic Medicine, Royal College of Surgeons, Ireland, &c.

[Read May 22, 1876.]

Whilst making lately some experiments on molybdic acid, I observed that when a solution of that substance in strong sulphuric acid was brought in contact with alcohol, there is very quickly developed a deep azure blue colouration; and this fact, being (as far as I was able to ascertain) hitherto unrecorded, led me to investigate the reaction to determine the cause of this production of colour.

As I found that the protosulphate of iron, and the protochloride of tin, two powerful deoxidizing salts, produced a similar effect on this solution, there was but little doubt that it was due to the deoxidizing action of alcohol on the molybdic acid. And I afterwards found that the blue substance which was formed in the case of alcohol possessed all the characters of the blue compound which is produced when molybdic acid or its salts are acted on by different reducing agents, whereby a substance consisting of five atoms of the metal molybdenum with fourteen of oxygen is obtained, which is usually regarded as a combination of the binoxide of molybdenum with molybdic acid, the following formula (MoO_2, 4 MoO_3) representing its composition.

With certain precautions which I shall presently point out, I have found that this reaction of alcohol on the molybdic solution stated is extremely sensitive, so that by its indications very minute quantities of alcohol, even when diluted with large proportions of water, may be readily detected. Thus, for example, if one part by volume of commercial rectified spirits be mixed with a hundred parts of distilled water, and one small drop of this mixture be taken, the minute quantity of spirit contained in it can be easily detected by the deep blue colouration which will be immediately developed on bringing it into contact with the molybdic solution, employed in the manner about to be described. But this is not the limit of the delicacy of this test, for I have been able by means of it to detect the spirit in one drop of a mixture of distilled water and anhydrous spirit, in which the latter substance constituted only the one-thousandth part of its volume; and as the drop was found to weigh six-tenths of a grain, the quantity of real or anhydrous alcohol contained in it would be less than the one-sixteen hundred and sixty-sixth part of a grain of that substance.

Though small quantities of spirit, even when considerably diluted with water, will produce with the molybdic solution the blue reaction without the assistance of any external heat, still where very minute quantities, diluted with such large proportions of water as those just stated, are to be detected, it is necessary for the success of the experiment that the reaction should be assisted by a gentle heat, and also that too great a dilution of the test solution with the liquid under examination should be avoided, as the blue colouration will not be developed if water be in excess; and even after it has been produced, the addition of a certain proportion of that substance quickly causes its disappearance. Such being the case, the best way of employing the test, according to my experience, is to place three or four drops of the molybdic solution in a small white porcelain capsule, and having heated them slightly, allow one or two drops of the liquid to be examined to glide or fall gently on the acid solution, when there will be developed, either immediately or after a few moments, the blue colouration. And where the alcohol is very largely diluted with water, it is better to continue the gentle heating of the test solution for some time, to concentrate it or expel as much water from it as possible, before adding the liquid to be tested, for in this way I have succeeded in detecting the spirit in mixtures so dilute, as to give no blue reaction when added immediately to the test solution on its being simply warmed. As regards the application of heat, I must observe that the temperature of the acid solution must not be raised too high, for if it be heated till the acid evolves its dense vapours, or begins to boil, the solution will of itself alone, from its partial decomposition, develope a more or less blue colouration, which will become more perceptible on its cooling. But such an occurrence can be easily avoided by employing a water-bath as the heating agent; for I have found that a temperature of 212° F. is incapable of so acting on the test solution—at least an exposure of several hours' duration to that heat failed to produce the slightest blue colouration, and a much lower temperature than that suffices for the application of the test.

I should here state that the molybdic or test solution which I have generally employed was made by dissolving at a gentle heat one part by weight of molybdic acid in ten parts of strong and pure sulphuric acid, but the exact strength of this solution as regards the amount of molybdic acid it contains seems to be immaterial.

I may observe that the colouration produced in the reaction stated disappears after a variable interval of exposure to the air—a circumstance which is due, as I have ascertained, to the absorption of moisture from the atmosphere, and not to the reoxidation of the molybdenum compound, as might have been supposed; for amongst other facts in proof of this, I may state that after it has thus disappeared, it may be readily restored either by expelling the water so absorbed by a gentle heat; or, more slowly, by placing the mixture under a desiccator, and thus removing it by spontaneous evaporation at the ordinary temperature. Such being the case, it is evident that, where the test solution has been too much diluted for the immediate development of the colouration described, expelling the excess of water by heating the mixture on a water-bath, it may be made to exhibit itself.

But the necessity for such evaporation should, if possible, be avoided, which in most cases will be so, by using only a drop or two of the liquid under examination, and by employing the strongest sulphuric acid in making the test solution; for it is very probable that much of the spirit contained in the liquid would be lost during its evaporation in the water-bath. Besides there would be some risk that the indications of the test might be more or less interfered with from particles of dust or organic matter getting into the mixture during that process.

The reaction which has been described, I should state, is not peculiar to ordinary or ethylic alcohol, but is, more or less, readily developed by others—at least I found it to be so in the case of methylic, propylic, butylic, and amylic alcohols, those being the only ones I had for my experiments. But it is more than probable that some at least of the other alcohols may act in a similar manner; however, the reaction is much more rapid and striking in the case of ethylic than in that of any of the other alcohols mentioned. I found also that certain salts of the radicles of those alcohols produced a somewhat similar reaction, as well as ethylic ether and aldehyde, and also several organic matters which are readily susceptible of oxidation.

The circumstance that the reaction described is not peculiar to ethylic alcohol will, no doubt, lessen its value as a positive test for that substance; but a similar objection appertains to all the other known tests for that compound, as their indications are not peculiar to that alcohol alone, if we except, perhaps, Berthelot's test, which is founded on the development of benzoic ether by the action of benzoic chloride, along with caustic potash on ethylic alcohol. But, owing to the trouble attendant on the preparation of benzoic chloride, and some other practical inconveniences connected with the application of that test, it is not likely that it will ever come to be one of very general employment.

The test, however, which I have brought before the Academy has this advantage over those already known, that it far exceeds (according to my experiments) any one of them in point of delicacy. And though the circumstance that the blue reaction produced in the case of this test is not peculiar to ethylic spirit lessens, as before observed, its value for the detection of that substance, this is just what renders the test of more general applicability; for by its aid certain impurities or adulterations may be at once detected in different substances or compounds, which in a state of purity should not contain any matter capable of acting on the molybdic solution employed in this test. I may refer to two important substances as examples, viz., chloroform and chloral hydrate, which are now so extensively employed in medicine and surgery for a number of useful purposes; and, being agents of great power, it is of much importance that they should be free from the accidental impurities of imperfect preparation, as well as from the frauds of intentional adulteration, which may either impair their therapeutic value, or even increase the danger of their administration. For there can be but little doubt that in some instances the serious and even fatal effects resulting from their use may, in part at least, have been attributable to the impurities or adulterations of the chloroform, or of the chloral hydrate employed. Now, as I find that neither chloroform nor chloral hydrate, in their pure condition, have any apparent action on the molybdic test, but that many of their usual impurities develope the blue reaction, it affords us a ready means of testing their purity. Thus, as regards chloroform, one of its common impurities is ethylic alcohol, which it may contain either from imperfect preparation, or from fraudulent addition, the very high price of chloroform offering a great temptation to the unscrupulous vendor to increase its bulk or weight by the addition of alcohol, which so readily mixes with it. I have found that the molybdic test at once enables us to detect such an adulteration, even where it occurs in very small proportions in chloroform. Thus, in one experiment, I mixed one part of rectified spirit with a hundred parts by volume of pure chloroform, and one drop of this mixture being brought in contact with three or four drops of the molybdic solution, previously warmed in a water-bath, gave an immediate deep blue colouration from the spirit contained in it; and, in a second experiment, with a mixture of one part of spirit to a thousand parts of chloroform, a single drop of the mixture, being similarly treated, developed a faint blue reaction. Indeed, so searching is this test as regards the purity of chloroform, that I was unable to obtain any sample of that substance in commerce sufficiently pure not to give a blue reaction with the molybdic test, owing to the minute quantities of volatile oils, and other impurities, they contain; and for my experiments I was obliged to repurify the commercially pure chloroform to obtain a sample which would give no coloured reaction with my test.

In the case of chloral hydrate, it is stated that one of its usual impurities is the chloral alcoholate (a compound in which alcohol, instead of water, is combined with anhydrous chloral), and that this substance has somewhat different effects on the system from those produced by the hydrate. This compound, owing to the alcohol it contains, gives the blue reaction with the molybdic test, and I have found that where the chloral hydrate contained even so small a proportion of the alcoholate as one part in a thousand parts, a little of such a sample, being taken, indicated its presence when examined by the molybdic test; and it is probable that some of the other impurities which are met with in this important substance may be similarly detected.

Those two examples are sufficient to indicate the use to which this test may be applied in the determination of the purity of different substances used in medicine, as well as in scientific research.

Finally, I would remark that, as the reaction of molybdic acid on ethylic alcohol is so sensitive and prompt in its action, I entertain the hope that there may yet be founded on it, not merely this qualitative test, but likewise a means for the quantitative determination of that important alcohol.

L.—On a New Genus and Species belonging to the Family Pandarina. By Edward Perceval Wright, M.D., F.L.S., Professor of Botany, Dublin University. (With Plate 35.)

[Read May 11, 1874.]

Rhinodon typicus, Smith, is one of the largest and one of the least known of the sharks. It was originally described by the late Sir A. Smith, from a young specimen about 17 feet long, found near Capetown. "It was the only one that had been seen at the Cape within the memory of any of the fishermen. At the time it was discovered, it was swimming leisurely near the surface of the water, and with a certain portion of the back above it. When approached, it manifested no great degree of fear, and it was not before a harpoon was lodged in its body that it altered its course and quickened its pace. The prepared specimen is deposited in the Museum of the Jardin des Plantes of Paris."*

The true habitat of this remarkable species appears to have remained unknown until during a visit paid to the Seychelles in 1867. I found it at home in the waters surrounding these pleasant islands. The size to which this great sluggish fish grows presents many obstacles to obtaining specimens of it. I have heard of some individuals being seen of about 70 feet in length; I have seen some that I believe to have exceeded 50 feet; my friend, Mr. Swinburne Ward, the then Civil Commissioner of these islands, measured one that a little exceeded 45 feet in length; and I have had the opportunity of dissecting two specimens, one of which was 18 feet long from the tip of the nose to the end of the caudal fin. Rhinodon typicus, though a large, is a quiet, harmless fish, with a mouth of immense width, and jaws furnished with very small teeth. I found large masses of algæ in their stomachs, so that at one time I was inclined to think it was an herbivorous shark. Probably, however, it derives its nourishment, in part at least, from minute crustaceans and other oceanic animal forms, which it may take in along with masses of floating weed, and then ejecting the water through the strange mesh-like structures that unite the edges of the great gill openings, obtain by so doing enough to swallow. Be this as it may, I found on the surface of these meshes the little parasitic crustacean, which it is the object of this paper to describe. The absence of parasites was remarkable. Some forty or fifty of the new form alone rewarded a very careful search. The sharks had been harpooned in the evening, and brought ashore by sunset (about 6 o'clock). Word was at once sent to me. I was at the time stopping exactly at the opposite side of the island,

* Illustrations of the Zoology of South Africa. By Andrew Smith, M.D. Pisces, Plate 26.

and was on the spot the next morning before sunrise, so that I was enabled to examine the specimen while it was still quite fresh. The following will serve as a diagnosis of the new form:—

Family—PANDARINA.

Rostrum longum, angustum. Palpi articulati, foliacei.

Stasiotes rhinodontis, gen. et spec. nov. (Plate 35, figs. 1 to 14).

The cephalothorax is nearly as broad as long, projected somewhat in front where the frontal lamina becomes conspicuous. It is very transparent, which will account for the markings to be seen on figure 2, where there is an appearance as if the cephalothorax were segmented. The sides project backwards, forming lobes so as to cover the free edges of the first abdominal ring. The first abdominal ring is narrow, not extending at either side so as to touch the prolongation of the cephalothorax. The second abdominal ring is somewhat broader and even wider, with delicately ciliated appendages, somewhat like those to be met with in Demoleus paradoxus, Heller. The last abdominal ring is furnished with very feebly developed wing-like projections, which lie slightly over the largely developed genital ring, the edges of these rings are clothed with bristle-like hairs.

The genital ring is rounded in the front and at the sides, obtusely truncated, and somewhat notched behind, a little less than one-half in length of the cephalothorax. The caudal ring is narrow—quite hid under the genital ring—but the caudal appendages (figure 14) are visible.

The anterior antennæ (figure 5) are biarticulate, and spring from the under surface of the frontal lamina; the first joint is twice as broad and as long as the second, and just behind its articulation with the second it is set over with a few minute bristle-like hairs; the second ends abruptly in two or three bristles. The posterior antennæ (figure 7) are stout and four-jointed; the third joint is twice as long as broad, and is barely covered by the front portion of the cephalothorax; the fourth joint consists of a long incurved claw. The rostrum (figure 6*a*) is long and narrow, consisting of two halves inclosed in a sheath each of which (figure 6*c*) is terminated by a series of tooth-like projections. The palpi (figure 6*a*) are small, feebly biarticulate, and very slightly foliaceous. The base of the rostrum with the palpi is situated between, and a very little below, the origin of the posterior antennæ.

The first pair of maxillary feet (figure 3) are of the shape and form usually met with in this group, but just at the base of the chelæ, and on their outer surface, there is a scale-like body (figure 8*a*), which is thickly set with short, stiff hairs of the same nature as those which are developed along the margins of the pincers. The second pair of maxillary feet (figure 9) are broad and large: the claw-like terminal joint can project beyond the edge of the cephalothorax; both the third and fourth claw-joint carry a stiff bristle.

The four pairs of abdominal feet are two-branched, and in the first three pairs each of these branches (figures 10, 11, and 12) are two-jointed, each of the joints being clothed with large bristles lined with hairs. The first pair possesses the smaller number of bristles, and there are no bristles on the first joints; the second and third pair have, on the inner edge of both the first joints, a well marked, long, ciliated bristle. The fourth pair (figure 13) is not fully furnished with bristles, and these are not clothed with ciliæ; and they are also not two-jointed, and in this, as in the number of bristles, differ very materially from the first three pairs.

The average length of the specimens examined is six millim. All the specimens met with were females.

In conformity with the practice of Heller, Steenstrup, Lutken, and others, I describe the swimming feet as abdominal—(abdominal fusspaare: bagkropsfodderne); but it would have seemed to me more natural to have described them and the somites from which they spring as thoracic. Heller gives* a conspectus of the Family Pandarina, including all the genera known to him. This new genus it appears to me might come in after Demoleus, the remi of the third pair not being 'biarticulati', and not being 'setis plumosis ornati.'

* Novara-Expedition. Zoologischer Theil: Crustacea, p. 160, about 1866.

LI.—Notes on a small Collection of Foraminifera from the Seychelles. By E. Perceval Wright, M. D., Secretary to the Academy.

[Read January 24, 1876.]

While at the Seychelles, in 1867, I made several collections of the Foraminifera met with while dredging. These were, for the most part, preserved in spirits of wine; and, unfortunately, were lost. One dredging, made in about eight fathoms of water, off the entrance of the Harbour of Port Victoria, between the Island of St. Anne and Long Island, was, however, preserved in a dry state; the bottom consisted for the most part of a coarse, white sand, mixed with fragments of shells, spicules of alcyonarians, and fragments of coral, and evidently contained numbers of Foraminifera. I am indebted to my friend Henry Bowman Brady, F. R. S., for the names on the following list:

Foraminifera.

1. *Cornuspira foliacea*, Philippi, sp.
   (1844, *Orbis foliaceus*, Enum. Moll. Sicil., vol. ii., p. 147, pl. 24, fig. 26). Medium-sized specimens, rare.
2. *Biloculina elongata*, d'Orbigny.
   (1826, Ann. Sci. Nat., vol. vii., p. 298, No. 1). Rare.
3. *Biloculina contraria*, d'Orbigny.
   (1846, For. Foss. Vienne, p. 266, pl. 16, figs. 4–6). Very rare.
4. *Triloculina trigonula*, Lamarck, sp.
   (1804, *Miliolites trigonula*, Ann. Mus., vol. v., p. 351, No. 3). Rare.
5. *Triloculina oblonga*, Montagu, sp.
   (1803, *Vermiculum oblongum*, Test. Brit., p. 522, pl. 14, fig. 9). Rare.
6. *Triloculina Brongniartiana*, d'Orbigny.
   (1840, Foram. Cuba, p. 156, pl. 10, figs. 6–8). Somewhat rare.
7. *Quinqueloculina seminulum*, Linné, sp.
   (1767, *Serpula seminulum*, Syst. Nat., 12th ed., p. 1264, No. 791). Rather common.
8. *Quinqueloculina subrotunda*, Montagu, sp.
   (1803, *Vermiculum subrotundum*, Test. Brit., p. 521). Rare.
9. *Quinqueloculina Ferussacii*, d'Orbigny.
   (1826, Ann. Sci. Nat., vol. vii., p. 301, No. 18—Modèle, No. 32).
10. *Quinqueloculina agglutinans*, d'Orbigny.
   (1840, Foram. Cuba, p. 168, pl. 12, figs. 11–13). Very common.

11. *Spiroloculina canaliculata*, d'Orbigny.
    (1846, For. Foss. Vienne, p. 269, pl. 16, figs. 10–12). Small, very rare.
12. *Hauerina compressa*, d'Orbigny.
    (1846, For. Foss. Vienne, p. 119, pl. 5, figs. 25–27). Small, very rare.
13. *Alveolina sabulosa*, Montfort, sp.
    (1808, *Miliolites sabulosus*, Conch. Syst., vol. i., p. 174). Medium, rather rare.
14. *Orbitolites complanata*, Lamarck.
    (1801, Anim. sans Vert., p. 376). Very common.
15. *Lagena squamosa*, Montagu, sp.
    (1803, *Vermiculum squamosum*, Test. Brit., p. 526, pl. 14, fig. 2). Small, very rare.
16. *Lagena marginata*, Walker and Jacob, sp.
    (1784, *Serpula* [*Lagena*] *marginata*, Test. Min., p. 3, pl. 1, fig. 7). Small, very rare.
17. *Globigerina bulloides*, d'Orbigny.
    (1826, Ann. Sci. Nat., vol. vii., p. 277, No. 1—Modèles, Nos. 17 and 76). Medium, rather rare.
18. *Textularia agglutinans*, d'Orbigny.
    (1840, Foram. Cuba, p. 136, pl. 1, figs. 17, 18, 32–34). Medium-sized specimens, common.
19. *Bolivina punctata*, d'Orbigny.
    (1839, Voyage l'Amér. Mérid., p. 63, pl. 8, figs. 10–12). Small, rare.
20. *Verneuilina spinulosa*, Reuss.
    (1849, Denkschr. Akad. Wissensch. Wien., vol. i., p. 374, pl. 47, fig. 12). Medium, rare.
21. *Planorbulina farcta*, Fichtel and Moll, sp.
    (1803, *Nautilus farctus*, Test. Micr., p. 64, pl. 9, figs. *g–i*). Medium, rare.
22. *Discorbina globularis*, d'Orbigny, sp.
    (1826, *Rosalina globularis*, Ann. Sci. Nat., vol. vii., p. 271, No. 1, pl. 13, figs. 1–4). Medium, rare.
23. *Pulvinulina repanda*, Fichtel and Moll, sp.
    (1803, *Nautilus repandus*, Test. Micr., p. 35, pl. 3, figs. *a–d*) Rare.
24. *Pulvinulina Canariensis*, d'Orbigny, sp.
    (*Rotalina Canariensis*, d'Orb., 1839, Foram. Canaries, p. 130, pl. 1, figs. 34–36). Very rare.
25. *Rotalia Beccarii*, Linné, sp.
    (1767, *Nautilus Beccarii*, Syst. Nat., 12th ed., p. 1162, No. 276). Small, rare.
26. *Rotalia orbicularis*, d'Orbigny, sp.
    (1826, *Gyroidina orbicularis*, Ann. Sci. Nat., vol. vii., p. 278, No. 1—Modèle, No. 13). Small, very rare.

27. *Cymbalopora Poeyi*, d'Orbigny, sp.
(*Rosalina Poeyi*, d'Orb., 1840, Foram. Cuba, p. 100, pl. 3, figs. 18–20). Large, very common.
28. *Tinoporus lævis*, Parker and Jones, sp.
(1860, *Orbitolina lævis*, Ann. and Mag. Nat. Hist., 3rd ser., vol. vi., p. 33, No. 7). Large, rare.
29. *Tinoporus vesicularis*, Parker and Jones.
(1860, *Orbitolina vesicularis*, Ann. and Mag. Nat. Hist., 3rd ser., vol. vi., p. 33, No. 5). Very rare.
30. *Patellina*, sp.
(A minute discoidal form, resembling a septate *Spirillina;* not corresponding with any figured species I can refer to. H. B. B.) Very rare.
31. *Amphistegina vulgaris*, d'Orbigny.
(1826, Ann. Sci. Nat., vol. vii., p. 305, No. 8—Modèle, No. 40). Small, common.
32. *Operculina complanata*, Defrance, sp.
(1822, *Lenticulites complanata*, Dict. Sci. Nat., vol. xxv., p. 453). (This thick *Operculina*, common in the Red Sea, Indian Ocean, and Australia, is not the typical *O. complanata*, but rather an intermediate form, showing the close relationship to *Nummulina planulata*). Medium size, rare.
33. *Nummulina planulata*, Lamarck, sp.
(*Lenticulites planulata*, Lamarck, 1804; Ann. Mus., p. 187, No. 1). Medium, rare.
34. *Polystomella crispa*, Linné, sp.
(1767, *Nautilus crispus*, Syst. Nat., 12th ed., p. 1162). Small, rare.
35. *Polystomella striatopunctata*, Fichtel and Moll, sp.
(1803, *Nautilus striatopunctatus*, Test. Micr., p. 61, pl. 9, figs. *a–c*). Small, very rare.
36. *Nonionina asterizans*, Fichtel and Moll, sp.
(1803, *Nautilus asterizans*, Test. Micr., p. 37, pl. 3, figs. *e–h*). Small, very rare.
37. *Nonionina scapha*, Fichtel and Moll, sp.
(1803, *Nautilus scapha*, Test. Micr., p. 105, pl. 19, figs. *d–f*). Medium, very rare.
38. *Heterostegina depressa*, d'Orbigny.
(1826, Ann. Sci. Nat., vol. vii., p. 303, pl. 17, figs. 5–7). Large, very common.

LII.—ON SOME FORAMINIFERA FROM THE LOO CHOO ISLANDS. By HENRY B. BRADY, F.R.S.

[Read May 8, 1876.]

A PRESSED and mounted specimen of a small alga, labeled "*Laurencia paniculata*, Loo Choo Islands," was recently sent to me by Dr. E. Perceval Wright, with the suggestion that some Foraminifera which had been entangled in its meshes might be worth examination, and that at any rate it would be interesting to know what particular species had lived amongst its miniature branches. As the seaweed itself was of some value, two or three square inches were taken, and the portion as separated yielded examples of the following species of Foraminifera, some of them in sufficient number to supply two or three good mountings.

Hauerina compressa, d'Orbigny.
Quinqueloculina subrotunda, Montagu.
,, *bicornis*, Walker and Jacob.
,, *ornatissima*, Kauer.
Peneroplis pertusus, Batsch.
Vertebralina stricta, d'Orbigny.
Orbitolites complanatus, Lamarck.
Discorbina rosacea, d'Orbigny.
,, *globularis*, d'Orbigny.
Planorbulina Mediterranensis, d'Orbigny.
Calcarina Spengleri, Gmelin.
,, *calcar*, d'Orbigny.
,, *hispida*, spec. nov.
Tinoporus baculatus, Montfort.
Cymbalopora Poeyi, d'Orbigny.
Heterostegina depressa, d'Orbigny.

Although a considerable list, considering that the entire weight of seaweed, shells, and all could not be more than fifteen or twenty grains, one or two forms were represented by a single specimen only, but no species has been retained of which a good characteristic example, large or small, was not present; doubtful forms were rejected, else the list might have been considerably extended. The most abundant species of Calcarina was the pretty hispid modification figured by Dr. Carpenter (Introd. Foram. Pl. xiv., fig. 6), but not hitherto described or named as far as I know. I propose to call this *C. hispida*, and its characters will stand as follow. I have met with larger specimens in Australasian sands, but have never seen any so beautifully perfect.

CALCARINA HISPIDA, *spec. nov.*—Test free, unequally biconvex, rotalian: margin, thin lobulate or rowelled; segments numerous, slightly inflated; peripheral borders thin, rounded, angular, or produced sufficiently to form radiating spurs. Surface covered with adpressed spiny processes, obscuring the sutures, except those of the later chambers. Diameter $\frac{1}{20}$ inch (1·3 mm.) or more. The characters are, indeed, very much those of *Calcarina calcar*, excepting for the superficial spiny armature.

Quinqueloculina ornatissima (Kauer, Sitzungsb. K. Akad. Wiss. Wien., 1868, vol. lviii., p. 151, pl. 3, fig. 2) deserves a passing notice. It is an interesting, highly ornate form with transverse crenulations, crossed by longitudinal striæ, and though I had previously found it in some Polynesian sands, it has not hitherto been recorded as a recent species. Dr. Kauer's specimens were from the Miocene of the Banat, in Austria. Only a single example was found in this Loo Choo gathering, and that is slightly broken.

At the time I received the seaweed from Dr. Wright, I was endeavouring to summarize what was known of the parasitic types of Foraminifera in connection with my work upon the Rhizopod-fauna of the carboniferous rocks, and I had arrived at the conclusion that adherent growth, at one period of life or another, was a much more common and more significant character in this group of organisms than has hitherto been supposed. It was, therefore, of interest to ascertain not only what species of Foraminifera were present, but how many of them, if any, were really parasitic, and not simply entangled in the meshes of the weed amongst which they had lived, or adherent by the mucilaginous matter coating the surface. The piece of the alga which had been separated, consisting chiefly of the root and the commencement of the larger branches, was therefore put into warm water and allowed to macerate for twenty-four hours, by which time it had swollen to its original size. Repeated sharp agitation during the maceration served to liberate most of the Foraminifera. It was then cut into little pieces, and the filaments of a conferva with which it had been associated in growth were carefully removed. The pieces were put into a sieve and washed under a strong stream of warm water from a tap, using every means even to the extent of some violence to dislodge anything that had not some connexion with the surface of the plant beyond mere chance adhesion. The specimens that remained were comparatively few in number, and pertained to a limited range of species, but for the most part they had evidently lived in the parasitic condition in which they were found. They were chiefly the young of *Orbitolites complanatus* and *Cymbalopora Poeyi* with small examples of *Planorbulina Mediterranensis*. The last-named needs no comment, as it is an essentially parasitic species, but I am not aware that either *Orbitolites* or *Cymbalopora* has ever before been noticed in this condition. The little specimens of *Cymbalopora* might have passed for the fry of one of the other rotalian genera but for the presence of larger specimens of the same species.

LIII.—REPORT ON IRISH HEPATICÆ. By DAVID MOORE, PH.D., F.L.S. (With Plates 43, 44, and 45).

[Read April 24, 1876].

HEREWITH I lay before the Academy the results of many years' researches among the Irish Hepaticæ.

Since I received the grant from the Academy, I visited in the early period of 1874 several parts of the County of Wicklow, which I supposed to be likely habitats of these minute plants, and among other places the glen of Altadore, or Hermitage Glen, near Delgany, where the rare Irish fern, Trichomanes radicans, once grew very sparingly, but has long since been eradicated. In the autumn of the same year, I went to Connemara, where I made a rather extended search among the mountains of that country, ascending to the top of Mweelrea, the highest in that district.

In May, 1875, I visited portions of the Counties of Fermanagh and Leitrim, where they join near Manorhamilton, and where I found the sides of the lakes and glens rather favourable for the growth of cryptogams, especially Hepaticæ. This district is in close proximity to the Ben Bulben range of mountains, upon which in Ireland is found the most distinct trace of a truly Alpine phanerogamic flora. On the high rocks between the heads of Glenad and Gleniff, Draba rupestris, Saxifraga nivalis, and Arabis petræa, all three truly Alpine plants, occur, not occurring elsewhere in Ireland. The faces of the cliffs are clothed, in many places, with two of the most lovely of our sub-Alpine species, namely—Saxifraga oppositifolia, and Silene acaulis; their rosy purple flowers can be seen at some considerable distance, and, on a nearer approach, appear patches of the rare Arenaria ciliata; this district being its only British locality. Here I gathered several rather rare Hepaticæ and mosses. In October I made another journey to the County of Kerry, where some great rarities among the Hepaticæ were collected, but very few not previously known to grow there.

This family of plants, like the Irish mosses, has been well studied and searched for by former botanists, both Irish and foreign. When it is remembered that the Counties of Kerry and of Cork are those in which dwelt two of the most gifted cryptogamic botanists that Ireland has produced, namely, the late Dr. Thomas Taylor, and Miss Hutchins of Bantry, it is not much to be wondered at that few discoveries remained for their successors. Of Miss Hutchins, Sir James Smith, when writing his English Flora, is reported to have said, "he believed she could find anything." To form some idea of her great success among the Hepaticæ, we have only to consult the pages of Hooker's "British Jungermanniæ," where her name is more or less connected with nearly every rare species contained in that grand work.

Dr. Taylor has given to the world the results of his researches among this interesting family of plants, in the second part of Mackay's "Flora Hibernica," where he describes, under the genus Jungermannia, all the species which were known to him up to 1836. Of the foliaceous kinds seventy-five species are enumerated, besides the Marchantiaceæ and Anthocerotaceæ, comprising eight species, eighty-three in all. Among them are several contributions of rare species by the late W. Wilson of Warrington, of bryological fame, who collected them in 1829, when he paid a long visit to this country, and who was the first to publish and describe in the English Flora the rare Dumortiera irrigua, under the name of Marchantia irrigua. After the publication of the "Flora Hibernica," Dr. Taylor discovered several new species, descriptions of which he published in the Transactions of the Botanical Society of Edinburgh, vols. 1–3. In 1843 a list of the Hepaticæ of the County of Cork was included in the Flora and Fauna of that county, which was published by the Cuvierian Society of Cork. About fifty species are therein enumerated. From that period up to 1862 little has been published on Irish Hepaticæ, except some brief notes of additional species and new localities by myself in the Proceedings of the Dublin University Botanical and Zoological Association, and of the Dublin Natural History Society. Isaac Carroll of Cork made also a few additions about this time.

In 1861 Dr. Carrington of Eccles, Lancashire, spent eleven weeks in Ireland, chiefly in the County of Kerry, studying and collecting Hepaticæ. In 1863 he published the result of his labours in the Transactions of the Botanical Society of Edinburgh, vol. 7, part III., under the heading, "Gleanings among the Irish Cryptogams." In this important contribution the names of the genera, and sections into which the large genus Jungermannia had been about that time subdivided, are adopted. He does not describe any new species, but he added to our flora one species, which had not previously been noticed in Ireland, namely, Jungermannia obovata, Nees. Including those which he found himself, and those which he gleaned from other sources, Dr. Carrington raised the list of Irish Hepaticæ to about 100 species, with numerous varieties. Another very important contribution has recently been published by Dr. Lindberg, Professor of Botany in the University of Helsingfors. At my invitation he paid a visit to Ireland in June and July, 1873, and was my guest while he remained in this country. I accompanied him to those parts of Ireland which I knew to be the richest in this particular family of plants, of which we made large collections. During the month of July 1873, no fewer than eighty-seven species of Hepaticæ were collected, an account of which Dr. Lindberg published in the Acta Societatis Scientiarum Fennicæ, vol. x.," under the heading, "Hepaticæ in Hibernia mense Julii 1873 lectæ." Among them he describes several species new to science, viz., Lejeunia patens, L. Moorei and Metzgeria conjugata. He also adds to the list Riccia sorocarpa, Bisch., and Scalia Hookeri (Lyell), Gray, besides raising to the rank of species a few which had previously been held as varieties.

Altogether, the subject is handled by him in a masterly way, and whether his new divisions and nomenclature be adopted or not by future botanists, his paper is a very important contribution to science. He divides the Hepaticæ into three sections. 1. Marchantiaceæ. 2. Jungermanniaceæ. 3. Anthocerotaceæ. This is no great departure from the arrangement of previous authors. These are again grouped under sub-sections, according to the nature of the valves of the capsule, whether splitting into pieces when ripe or remaining whole, viz., Schizocarpæ and Cleistocarpæ.

The Jungermanniæ Schizocarpæ are divided into two principal divisions differing from each other in several important characters, which are fully described, but chiefly depend on the position which the Gamœcium and Androecium occupy on the plants. These he calls (*a*) Anomogamæ; (*b*) Homogamæ, and the latter he still further divides into * Opisthogamæ; and ** Acrogamæ. By these divisions he has been enabled, in my opinion, to group the species together more naturally (with a few exceptions) than has been done by any previous author. What may, however, be found fault with is Dr. Lindberg's endeavour to restore the names of genera in exact conformity with the law of priority. The dates are so carefully and clearly set forth along with the name of each genus, that there can be no disputing the matter. It is well known that Mr. S. F. Gray, father of the late Dr. J. E. Gray, of the British Museum, was the first to subdivide the comprehensive genus Jungermannia into smaller genera, to which he gave names in his "Arrangement of British Plants," published in 1821, a fact which had already been established by Mr. Carruthers, Director of the Botanical Department, British Museum, in Seemann's Journal of Botany, vol. iii., p. 297. These names of Gray's Dr. Lindberg has in many instances adopted, though some of them sound very oddly, after we have been so long accustomed to the established nomenclature of such a standard work on Hepaticæ as the "Synopsis Hepaticarum," by Drs. Gottsche, Lindenberg and Nees, published between 1844 to 1847. That there is a farther want of some recognised standard in the nomenclature of this family of plants is obvious, and may be seen from the numerous synonyms of various authors which Lindberg and Du Mortier have brought together.

The veteran Belgian Botanist, M. Du Mortier, having published his first work on Hepaticæ, "Commentationes Botanicæ," so long back as 1822, and others of importance on the same subject, at intervals from that period till 1874, when his large work "Hepaticæ Europæ" was published, has all that time been altering and improving the distinguishing characters of the sub-orders and so-called genera of this family of plants, yet in the last work new divisions and new names of genera are to be found.

The characters of Hepaticæ, though pretty constant, and sufficient to distinguish the genera, are by no means so satisfactory as those of the Mosses. Dr. Taylor, all his life, held the opinion that it was impossible to distinguish satisfactorily the genera of Jungermannia from the descriptions given of them, and he never adopted them, but continued to name his new species as they occurred to him by the old established generic name Jungermannia up to the last, though he knew they belonged to genera established by modern authors. Even the late Sir William Hooker, who studied the British Jungermannia with a rare discriminating power, did not attempt to divide the old genus Jungermannia, but was content to place the species in natural groups, which are pretty much the same as those now adopted, several of them being represented by modern genera. His great work on the British Jungermannia is, indeed, one of the most beautiful and most exhaustive ever written on any subject of natural history. In the present Report, I have adopted Dr. Lindberg's arrangement, both for the sake of uniformity, and because I consider it the most natural yet published.

Ireland is extremely rich in this family of plants, and produces a number of remarkable species, which are true indicators of the climate of the country. These minute vegetables, some of which are scarcely visible to the unaided eye, tell of heat, moisture, and other climatal circumstances, much more accurately than the flowering plants of the country do, and show that the south-west of Ireland approaches in climatal conditions some sub-tropical parts of the world.

In a letter from the well-known traveller, Dr. Spruce of Welburn, Yorkshire, who has explored a very large portion of South America, collecting both the flowering and cryptogamic plants of that country, he states that "when gathering mosses and Hepaticæ on the slopes of the Andes, he was reminded of the Kerry Mountains, whose cryptogamic vegetation is the nearest approach in Europe to that of tropical mountains." Among the species most characteristic of a warm and moist climate, I may mention particularly Dumortiera irrigua, Radula xalapensis (Radula voluta, Taylor), found also in New Granada, Metzgeria linearis, which grows also in Jamaica, and Guadaloupe, Frullania Hutchinsiæ, variety β., in the Island of Java, and the minute Lejeuniæ. Among the mosses we have the beautiful Hookeria lætevirens, which occurs in the West Indies, besides the Killarney Fern (Trichomanes radicans), another plant which extends to the West Indies.

I have spared no trouble to ensure correctness in the names of the plants, for which purpose I have frequently consulted both Dr. Carrington and Professor Lindberg, who have always very kindly assisted me with their opinion.

The Irish habitats may be relied upon, as I have collected nearly every one of the plants with my own hands, at some time or other during the last forty years; having for this purpose travelled over a very large portion of Ireland, from east to west, and from north to south, and from the sea-level to the tops of the highest mountains. The chief merits of this Report may indeed be considered to consist in its giving as full an account as I am able to render of the Irish Hepaticæ, and of their geographical distribution in Ireland. 137 species of them are enumerated.

IRISH HEPATICÆ.

SECTION I. FRONDOSÆ. MARCHANTIACEÆ.

Plants with stems and leaves confluent in a frond.

A. SCHIZOCARPÆ.

Family 1. MARCHANTIEÆ.

Capsules in aggregate capitula, pendent from a peltate receptacle.

Diœcious.—Male receptacle pedunculated. Loculi of the female receptacle 2-valved. Colesule 4–5 cleft, ... MARCHANTIA.

Diœcious.—Fertile receptacle hemispherical, ribbed in a ray-like manner, and lobed, involucres attached to the under side of the lobes, 1–3 fruited. Male receptacles peltate, peduncled, with the antheridia immersed, ... PREISSIA.

Diœcious.—Male receptacle sessile, disciform. Loculi of the female receptacle tubulose, 1–fruited. Colesule wanting, . . CONOCEPHALUS.

Monœcious.—Antheridia immersed in sessile crescent-shaped disks on the frond. Fertile receptacle, 4–5 lobed. Loculi 4–5, single-fruited. Colesule wanting, . ASTERELLA.

Diœcious.—Male receptacle almost sessile, peltate, hairy. Female receptacle hairy, elevated on a peduncle, 2- to 6- cleft. Loculi 1–valved. Colesule wanting, . DUMORTIERA.

Diœcious.—Male receptacle sessile. Female receptacle deeply cleft. Loculi tubulose, 1–valved, fleshy. Colesule wanting, . LUNULARIA.

Family 2. TARGIONIEÆ.

Capsules solitary, situated near the apex of the frond, subsessile, bivalved, without a central columella.

Diœcious.—Male receptacle sessile, in a bivalved loculus. Capsule shortly pedicellated, situated near apex of frond, opening irregularly, ... TARGIONA.

B. CLEISTOCARPÆ.

Capsules valveless, imbedded in the substance of the frond. No Elaters.

Family 3. RICCIEÆ.

Fruit immersed in upper surface of frond, bearing a style, which is protruded above the surface of the frond, . . .	RICCIA.
Fruit globose, adnate to under surface of frond. Style exserted, ...	RICCIELLA.
Fruit immersed in frond, and not protruded on either surface, ...	RICCIOCARPUS.

SECTION II. FOLIOSÆ. JUNGERMANNIACEÆ.

Plants with stems and leaves distinct.

A. SCHIZOCARPÆ.

Capsules solitary, elevated on an erect foot-stalk, or subsessile. Elaters with spiral fibres.

Sub-tribe 1. FRULLANIEÆ.

Involucral bracts wanting or indistinct.

Colesule trigonal, rarely round, constricted at the mouth, slightly keeled beneath. Involucral bracts wanting or imperfect. Elaters single-spired, ...	FRULLANIA.
Colesule contracted at the mouth, angular or toothed. Peduncle articulated. Capsule univalved. Elaters double-spired, . .	LEJEUNIA.
Colesule compressed, truncate. Involucral bracts wanting or indistinct. Peduncle not jointed. Elaters with double spires, .	RADULA.
Colesule compressed, slightly bilabiate. Capsule univalved, globular or cleft. Elaters double-spired, ...	PORELLA.

Sub-tribe 2. PLEUROZIEÆ.

Involucral bracts present and distinct.

Involucral bracts two, deeply bilobed. Colesule long, cylindrical, mouth denticulate, decurved at apex. Capsule quadrivalved, of thick texture. Elaters double-spired, .	PLEUROZIA.

Sub-tribe 3. LEPIDOZIEÆ.

Involucre polyphyllous, bracteolæ in several rows. Colesule sulcate, toothed, . .	LEPIDOZIA.
Involucre polyphyllous, bracteolæ scale-like, imbricated on every side. Colesule cylindrical, mouth compressed. Pedicels not jointed. Capsule 4-valved. Elaters two-spired, naked, ...	BAZZANIA.
Involucre polyphyllous, bracteolæ bilobed, imbricated. Colesule cylindrical, cleft at side, mouth denticulate. Capsule 4-valved. Pedicels continuous, . .	ODONTOSCHISMA.
Involucre polyphyllous, bracteolæ variously ciliated and lacerate. Colesule sessile, round, inflated, denticulate, and contracted at mouth, ...	CEPHALOZIA.
Involucre oligophyllous, segments deeply divided. Colesule sessile, roundish, trilobed, and crested at mouth, . . .	LOPHOCOLEA.
Involucre polyphyllous, larger than stem leaves, margins undulate and recurved. Colesule obovate, mouth compressed, crenate denticulate, ...	PEDINOPHYLLUM.
Involucre polyphyllous, bracteolæ scale-like, imbricated. Colesule cup-shaped, bilabiate. Calyptra exserted,. . .	CHILOSCYPHUS.
Involucre oligophyllous, segments deeply lobed. Colesule fusiform, 3–4 cleft at mouth. Pedicels inarticulate, . .	HARPANTHUS.

Sub-tribe 4. SACCOGYNEÆ.

Involucral bracts wanting. Colesule pendulous from under side of stem, smooth, mouth circular, undulated, . . .	SACCOGYNA.
Involucral bracts wanting. Colesule pendulous, hairy, attached by the margin of the apex to the stem, ...	KANTIA.

Sub-tribe 5. BLEPHAROZIEÆ.

Involucral bracts wanting. Colesule pedunculate, hairy all round, wide-mouthed, margin of mouth toothed, . . .	TRICHOCOLEA.
Involucral bracts 2–3 lobed and ciliated. Colesule club-shaped, inflated, mouth contracted and denticulate, ...	BLEPHAROZIA.

Involucre polyphyllous, bracteolæ imbricated, undivided. Colesule sessile, round, trisulcate, mouth denticulate, . . .	MASTIGOPHORA.
Involucre polyphyllous, bracteolæ much cut and connate at base. Colesule wanting. Capsule 4-valved, smooth, of thick texture, ...	HERBERTA.
Involucre polyphyllous, bracteolæ imbricated all round, palmately cut. Colesule sessile, roundish, denticulated at mouth, . .	ANTHELIA.
Involucre polyphyllous, bracteolæ imbricated, articulately ciliated. Colesule sessile, erect, roundish ovate, mouth clothed with long acute cilia, ...	BLEPHAROSTOMA.

Sub-tribe 6. JUNGERMANNIEÆ.

Involucre diphyllous, segments bilobed, conduplicate. Colesule dorsally compressed, mouth truncate, bilabiate, at first decurved. Elaters bispiral, attached to centre of the valves, ...	SCAPANIA.
Involucre oligophyllous, segments bilobed, margin entire. Colesule sessile, erect, round, mouth denticulate. Capsule coriaceous, ...	DIPLOPHYLLUM.
Involucre diphyllous, bracteolæ convex, undivided. Colesule laterally compressed, mouth oblique, truncate, toothed or fringed. Elaters bispiral, thread-like, .	PLAGIOCHILA.
Involucral bracts two, connate at base. Colesule ovate oblong, laterally compressed. Capsule 4-valved, of thick texture, ...	MYLIA.
Involucral bracts several, cut and bifid, distinct from the cauline leaves. Colesule terminal on stem or short branches, tubulose, more or less plaited, laciniated and contracted at mouth. Calyptra free within the colesule, ...	JUNGERMANNIA.
Involucre polyphyllous, bracteolæ forming an urceolate receptacle, connate with the colesule and connecting tissue of the thalamus, ...	NARDIA.
Involucral bracts double, larger than cauline leaves, inclosing the immersed calyptra. Colesule wanting, ...	CESIA.

Sub-tribe 7. ACROBOLBEÆ.

Involucre terminal on torus, bulbous and rooting from underside. Colesule wanting. Calyptra adhering to the bulbous base of the receptacle, ... ACROBOLBUS.

Sub-tribe 8. FOSSOMBRONIEÆ.

Involucral bracts two, opposite. Colesule wanting. Calyptra exserted, cylindrical, longer than involucral bracts. Capsule of thick texture. Elaters single-spired, . . SCALIA.

Involucre scale-like or wanting. Colesule campanulate, wide-mouthed, margin undulate or lobed. Capsule one-valved, globose, bursting irregularly, . . FOSSOMBRONIA.

Involucre connate with the colesule. Colesule angularly campanulate, mouth wide, undulate-dentate. Capsule sphæroid, bursting irregularly, ... PETALOPHYLLUM.

Involucre monophyllous, cut and lacerated. Colesule tubulose, exserted. Calyptra irregularly torn at the apex. Capsule oval. Andrœcium dorsal on the midrib of the frond, ... PALLAVICINIA.

Involucre undivided, bladder-shaped, attached to apex of frond. Colesule inclosed within the utricular involucre. Andrœcium immersed in the frond, and covered with dentate scales, ... BLASIA.

Involucre cup-shaped, toothed, and lacerated at the mouth. Colesule wanting. Calyptra oval, membranous. Andrœcium immersed in the upper surface of midrib of frond, . PELLIA.

Sub-tribe 9. METZGERIEÆ.

Involucre monophyllous, scale-like, ventricose, and two-lobed. Colesule wanting. Calyptra ascending, oblong-ovate, echinate. Inflorescence diœcious. Antheridia inclosed by a 1-leafed involucre on the under side of midrib, ... METZGERIA.

Involucre cup-shaped, short, lacerate. Colesule wanting. Calyptra exserted, globous. Inflorescence diœcious. Capsule 4-valved, of thick texture. Elaters persistent. Antheridia immersed in receptacles, proceeding from margin of frond, . RICCARDIA.

B. CLEISTOCARPÆ.

Sub-tribe 10. SPHÆROCARPEÆ.

Capsule without valves, globular, free, immersed in the membranous frond. Elaters and Colesule wanting, ... SPHÆROCARPUS.

SECTION III. ANTHOCEROTACEÆ.

Capsule solitary, filiform, bivalved, stalked, with a free central placentation.

Family 1. ANTHOCEROTEÆ.

Colesule tubulose. Capsule 2-valved, linear, elongate, pedicelled, with a free central placentation. Elaters imperfect, . . ANTHOCEROS.

SECTION I. MARCHANTIACEÆ.

A. SCHIZOCARPÆ, Lindberg.

Family 1. MARCHANTIEÆ.

Perennial plants with spreading fronds, more or less carnose, lying flat on the ground, and clothed more or less beneath with imbricating scales, which are frequently coloured, among which numerous rootlets issue. Diœcious for the most part. Female receptacle raised on a peduncle, springing from near the apex or back of the frond, radiate or capitate, with loculi. Colesules present or wanting. Male receptacle elevated or sessile, smooth or hairy.

MARCHANTIA, Linneus.

Male receptacle pedunculated, furnished with scales beneath. Female receptacle rayed, involucres alternate with the rays, 1–3 flowered; bivalved. Colesule 4–5 cleft. Calyptra bursting, remaining within the colesule.

Marchantia polymorpha, Linn. Fertile receptacle deeply cut, star-like, into eight or ten divisions. Male receptacle peltate, undivided.

Marchantia polymorpha, Linn. Sp. Pl. 1603. Marchant fil in Acta Gal. 1713; Micheli, Nov. Pl. Gen. t. 1, figs. 1, 2, 5; Dill. Musc. t. 76; and t. 77, fig. 7; Engl. Bot. t. 100; Musc. Brit. ed. 2, p. 2, p. 219; Lindenberg, Synop. Hep. Europ. p. 100; Taylor, in Fl. Hib. p. 49; Dumortier, Hepaticæ Europæ, p. 150.

Hab. In moist situations generally, sometimes in dry places. Especially abundant on the surface mould of pots in the Botanic Gardens, where it is frequently subjected to high temperatures, under which treatment both male and female receptacles are abundantly produced.

CONOCEPHALUS, Neck. Dmrt.

Marchantiæ sp. Linn. Sp. Pl. (1753). Conocephalus, Neck. Elem. Bot. III., p. 344 (1790). Dmrt. Comm. p. 115 (1822). Fegatella, Raddi, in Op. Scient. di Bologna, II. 356 (1818). Nees, Europ. Leberm., 4, p. 170.

Diœcious. Fertile receptacle conical or mitriform, covering the loculi, which are from 4–5, and monocarpous, opening with a vertical fissure. Colesule wanting. Calyptra bell-shaped, persistent in the loculus. Antheridia immersed in sessile oval disks, near the apex of the frond.

Conocephalus conicus, Neck. Dumort. Fronds large, varying much in width, crenate, undulate at the margins. "Buds appear in winter between the terminating lobes, their margins involute, the entire ascending, recurved, at length opening into light, shining, green fronds. The scales beneath are subrotund, oblique, slightly emarginate. The male receptacle is hemispherical and smooth below, nearly flat above, immersed in a cavity of the frond, but not adhering to it except by a central point at the bottom; the upper surface is rough, with conical elevations, the tops of whitish antheriferous vesicles; the anthers are linear, oblong, coming to maturity the summer previous to the ripening of the seeds; female receptacles fully formed in October remain sessile on the fronds until the following February, when at length the peduncles arise."—Taylor, in Flora Hibernica.

Marchantia conica, Engl. Bot. t. 504, Musc. Brit. ed. 2, p. 221. Conocephalus conicus, Dumort. Hepat. Europ. p. 155. Conocephalus vulgaris, Bisch. in Nov. Act. Nat. Curios. 17, p. 979. Fegatella conica, G. L. et N. Synop. Hepat. 546; Rabenhor. Hep. Europ. exsic. &c., 299–329.

Hab. Damp shady places, where the mass of fronds sometimes spread over several feet in diameter continuously. If taken in and put in a pot or box, covering the surface with a pane of glass, the latter will after a few days become more or less covered with the antheridia, which are jerked out of their receptacles with such force as to make them adhere to the covering glass.

PREISSIA, Nees.

Preissia, Corda, in Opiz, Naturalientausch (1829); Nees, Europ. Leberm. (1838).

Diœcious. Fertile receptacle angularly hemispherical, 2–4 lobed, loculi attached to the under side of the lobes, 1–3 fruited, dehiscing irregularly. Colesule obconico-campanulate, 4–5 lobed. Calyptra persistent. Capsule pedicelled, dehiscing by revolute segments. Antheridia immersed in a peduncled peltate receptacle.

Preissia commutata, Nees. Frond oblong, sinuate, frequently bilobed at the apex, from 1–3 inches long, varying very much in width, according to locality. Fertile receptacle peltate, hemispherical, with keel-like rays. Capsule globose, shortly pedicellate, often of a dark purple colour. Barren receptacle peltate, peduncled.

Marchantia hemisphærica, Linn. Fl. Suec., No. 1052. Conocephalus hemisphæricus, Dmrt. Comm. Bot., p. 113. Marchantia commutata, Lindenb. Hep. Europ., p. 101. Preissia Italica, Corda, in Opiz, Natural., p. 647. Preissia commutata, Nees, Europ. Leberm., 4, 117; G. L. et N. Synop. p. 539; Rabenh. Hep. Europ. exsic. n. 5, 125, 141, 330, 481; Engl. Bot. t. 2545, exclude figs. at under portion of plate; Carrington, Irish Hepat. Trans. Bot. Soc. Edin. vol. 7, p. 443.

Hab. Fissures of damp rocks, and on damp ground in mountainous parts of the country, particularly in limestone districts; occasionally on sandy ground near the sea, as at North Bull, near Dublin. Frequent in Co. Galway. Rocks above Kylemore Castle, and by the side of the lake at Letterfrack; abundant near Cong; Sillaghbraes, near Larne, Co. Antrim; Co. Kildare; Co. Kerry, about Killarney, &c., &c. The variety minor on high limestone ridges of the Benbulben range, Co. Sligo. Glendine wood, Co. Waterford, Isaac Carroll, Esq.

DUMORTIERA, Nees.

Marchantia, Sw. Prodr. Fl. Ind.-Occ. p. 145 (1788). Dumortiera, Nees, in Nov. Act. Acad. Cæs.-Leop. 12, p. 1, p. 410 (1823). Lunularia? N. B. in Flora, 13, p. 2, p. 401 (1830). Hygrophila, Taylor, in Fl. Hib. p. 2, p. 53 (1836). Spathysia, Nees, Nat. Eur. Leberm. 4, p. 178 (1838).—Lindberg.

Diœcious. Male receptacle very shortly pedunculated, peltate, hairy. Fertile receptacle convex, pedunculated, hirsute, with scattered hairs. Colesule wanting, loculi univalved, opening at the top by a vertical fissure at the outer extremity. Frond without pores.

Dumortiera irrigua, Nees. Fronds large, varying from 2 to 5 inches in length, and nearly an inch in width, membranaceous, bilobed, margins slightly undulate, of a bright lively green colour, and without pores. Fertile receptacle and involucres hairy, raised on rather long peduncles, which are chaffy at the apex. Male receptacles thick, carnose, and nearly sessile, beset with a number of hair-like scales, which entirely cover the young receptacle, they are flat, and recurve in a radiating spiral manner, tapering to a point. These scale-like hairs proceed from the short peduncle, and cover the base of the receptacle.

Marchantia irrigua, Wilson, in Hook. Engl. Fl. 5, 1, p. 106. Hygrophila irrigua, Taylor, in Fl. Hib. p. 54. Dumortiera, Reinw. Bl., et Nees, in Nov. Act. Natur. Cur. 12, p. 410; Dumort. Hepat. Europ. p. 153 (1874).

Hab. Sheltered, shady, rocky recesses, where water is constantly trickling over, or otherwise very moist. Blackwater bridge, near Dunkerron, Dr. Taylor (1820). Torc waterfall, near Killarney. Maghanabo glen, near Fermoyle, Co. Kerry, W. Wilson, Esq. (1829), who first published the plant as a native of the British Isles, in English Flora (1833). Ballinahassig glen, near Cork, Fl. Cork. Dunscombe's wood, I. Carroll. Altadore glen, near Delgany, Co. Wicklow, the Right Hon. Lord Gough. We have collected it in the same glen, 1872 and 1874; also very sparingly near a small waterfall at Luggielaw, Co. Wicklow. This remarkable plant is very local in Ireland, and only occurs in the warmest and most sheltered spots. It is amenable to cultivation, and under proper management produces both male and female receptacles rather freely, as has been the case in the Glasnevin Botanic Gardens during a number of years.

ASTERELLA, Beauv.

Marchantia, Linn. Sp. Pl. 1 ed., 2, p. 1138; Fl. Lapp. (1753). Asterella, Beauv. in Encycl. Meth. Suppl. 1, p. 502 (1810). Reboulia, Raddi, in Opusc. Scient. di Bologna, II., p. 357 (1818). Conocephalus, Dumort. Comm. Bot., p. 115 (1822).

Monœcious. Frond rigid, with a broad and distinct midrib. Fertile receptacle hemispherical, 4-5 lobed, barbate beneath. Colesule wanting. Calyptra minute, lacerate, persistent at the base of the capsule. Capsule globose, rupturing irregularly. Antheridia immersed in sessile crescent-shaped disks.

Asterella hemisphærica, Beauv. Frond bilobed or dichotomously divided at apex, margins crenate, depressed, more or less obviously scariose beneath, with purplish scales. Fertile receptacle barbate beneath and at apex of pedicel, with long white silky hairs. Antheridia sessile, in crescent-shaped disks.

Marchantia hemisphærica, Linn. Sp. Pl. 1604; Smith's Engl. Bot. t. 503. Asterella hemisphærica, Beauv. Encycl. Meth. Suppl. p. 502; Lindberg, in Not. pro. Faun. Fl. Fennica, IX. p. 286. Asterella hemisphærica, Dumort. Hep. Europ., p. 154 (1874).

Hab. On damp rocky places, walls of bridges, and on damp sandy ground. Dunkerron, Co. Kerry, Dr. Taylor. Dingle bay, Dr. Carrington. Near Cork, and Fermoy, Isaac Carroll, Esq. Abundant on the walls of the bridge at Cong, Co. Galway; at Sillaghbraes, near Larne, Co. Antrim; on sandy ground at the North Bull, near Dublin, David Macardle. This plant is found occasionally in the vicinity of its near ally Preissia commutata, Nees, from which the barbate under side of the fertile receptacle, and of the apex of the pedicel, and the sessile male flowers are ready and obvious characters which will always distinguish it.

LUNULARIA, Micheli.

Lunularia, Mich. Nov. pl. gen. p. 4, tab. 4 (1741); Raddi, in Opusc. Scient. di Bologna, II., p. 353 (1818). Marchantia cruciata, Linn. Sp. Pl. (1753).

Diœcious. Fertile receptacle deeply divided into narrow loculi, loculi tubulose, opening with a horizontal fissure. Capsule 4-valved, exserted. Male receptacle sessile, with a membranaceous elevated margin.

Lunularia cruciata, Linn. Dumort. Fronds gregarious, 1 to 3 inches long, lobed and variously divided, waved and elevated at the margins, cuticle rough, with elevated pores, under surfaces more or less covered with scariose scales. Gemmiferous scyphi occur on surfaces of both male and female fronds in lunulate or crescent-shaped disks, at all seasons of the year. Fertile receptacle pedunculated, globular when young, at length quadrifid, the loculi of which open by a horizontal fissure, and are usually four in number. Colesule wanting. Calyptra rupturing, and remaining in the bottom of the loculus. Male receptacle sessile, immersed in the frond and situated at the top of the sinuses. The ovate anthers are easily removed from the mass, they are ovate, with a grumose centre, and have a broad pellucid border.

Lunularia vulgaris, Micheli, Nov. Gen. 4, t. 4. Marchantia cruciata, Linn. Sp. Pl. 1604; Haller, St. Helv. (ed. 1768), tom. 3, p. 65, No. 1888; Huds. Fl. Angl. p. 52; Wither, Syst. Arr. Br. Pl. ed. 1801, vol. 3, p. 869. Lunularia vulgaris, Taylor, in Fl. Hib. p. 52 (1836). L. cruciata, Dumort. Hepat. Europ. (1834); Lindberg, Hepat. in Hibernia lectæ (1875).

Hab. Damp ground, and on moist limestone walls; not very common. At Altadore glen I have observed continuous patches upwards of a yard in extent, yet not a single exserted female receptacle on them, though both sexes occur there. I have only once seen good fertile receptacles produced, which happened in Glasnevin Botanic Garden. They were sent to be figured for the supplement to English Botany, and a pretty good figure was made, which, however, has never been published.

Family 2. TARGIONIEÆ, Dumort.

Involucre bivalved, sessile near the apex of the frond, monocarpous. Male receptacle in a terminal bivalved loculus.

TARGIONIA, Micheli.

Diœcious. Involucre on the under side of the frond, sessile near the apex. Capsule shortly pedicellate, opening vertically by two marginate valves. Male receptacle on narrow short fronds, near their extremities, similar to the female capsules, but smaller, in which the antheridia are imbedded in a carnose disk.

Targionia hypophylla, Linn. Fronds closely packed together, somewhat imbricated, 1 to 2 inches long, narrow, almost linear throughout, obovate at apex, concave, margins purplish black, nearly entire, of a dull green colour, the cuticle rough with raised pores, purplish lunulate scales occur on each side of the midrib as in the other Marchantieæ. Fertile involucre large, compared with the size of the whole plant, and conspicuous at the apex of the fronds.

Targionia hypophylla, Linn. Sp. Pl. 1604; Web. et Mohr. Jr. Germ. p. 391, t. 12; Engl. Bot. t. 287; Lindenb. Synop. Hep. p. 110; Hook. Brit. Fl. II. p. 55; Raddi, in Opusc. Scient. di Bologna, II. 359; Taylor, Fl. Hib. pt. 2, p. 55. Targionia Michelii, Corda, in Opiz, Natur. in Sturm, Deuts. Crypt. fasc. 22, p. 73, t. 20; Nees, Europ. Leberm., 4, p. 299; G. L. et N. Synop. Hep. p. 574; Rabenh. Hep. Eur. exsic., n. 376, 546.

Hab. On warm dry rocks. On the cave hill at Belfast, John Templeton, Esq. On dry limestone rocks, Carrigaline, near Cork, Isaac Carroll, Esq. On the warm basaltic rocks at Deerpark, Glenarm, Co. Antrim, 1834, D. M. A good specimen from the latter locality is in the Herbarium of the College of Science, Dublin. This plant is of rare occurrence, and very local in Ireland.

B. CLEISTOCARPÆ, Lindberg.

Family 3. RICCIEÆ, as emended, Lindberg.

Terrestrial or aquatic plants. Fruit immersed in the frond. Style protruded above the frond. Colesule and Elaters wanting. Spores with pellucid coats.

RICCIA, Micheli.

Riccia, Micheli, Nov. Pl. Gen. p. 6, tab. 4, fig. 6 (1729); Linn. Sp. Pl., 1 ed., 2, p. 1138 (1753). Riccardia, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 684 (1821). Targionia, Braun, in Flora, 4, p. 2, p. 756 (1821). Ricciella, Braun, in Flora, 4, p. 2, p. 756 (1821). Ricciocarpus, Corda, in Opiz, Beitr. I. p. 651, n. 21

(1829). Salviniella, Hübener, Hep. Germ. p. 30, inter Synon. (1834).—Lindberg.

1. *Riccia glauca*, Linn. Frond stellately bilobed, divisions linear, dichotomous, emarginate, fleshy, punctate, membranaceous at the margin, from ¼ to 1 inch long. Capsules immersed in the upper side of frond, with brownish black opaque persistent styles.

Riccia glauca, Linn. Sp. Pl. 1605; Engl. Bot. 2546; Lindenb. Monogr. Ricc. p. 417, t. 19; Nees, Eur. Leberm. 4, p. 393; G. L. et N. Synop. Hepat. p. 599; Taylor, in Fl. Hib. II. p. 70.

Hab. On damp ground, where water has stood during winter; wet hedge banks, and scattered in more or less abundance over the whole of Ireland.

2. *Riccia sorocarpa*, Bischoff. Frond solid, somewhat trigonous, glaucous green on both surfaces, subdichotomous, divisions thick and fleshy, margin glabrous, inflexed when dry, upper surface canaliculate when dry, mid vein distinct. Fruit immersed when young, at length bursting the epidermis, and allowing the spores to escape.

Riccia sorocarpa, Bisch. in Nov. Act. Nat. Cur., 17, p. 1053 to 71, f. 11; G. L. et N. Synop. Hepat., p. 600; Rabenhor. Hep. Europ. exsic. n. 28, 543; Dr. Braithwaite, in Grevillea, for March (1873), p. 144; Dr. Carrington, in Grevillea, for December (1873), p. 86, pl. 18; Professor Lindberg, in Hepat. in Hibern. lectæ, p. 471 (1874).

Hab. Fissures of moist walls, &c. On an old wall near Dingle, Co. Kerry, July (1873), Professor Lindberg.

RICCIELLA, Al. Braun.

Riccia, Sp. L. Ricciella, Braun, in Bot. Zeit. (1821); Lindenb. Synop. Hepat.; Dumort. Hepat. Europ. (1874).

"Fruit globose, protuberant from the lower surface of the frond, and inserted on it."—Dumort. Frond spongy, mixed with large air cavities, floating.

Ricciella fluitans, Al. Braun. Frond linear, plane, dichotomously forked, radiating in a stellate manner, thickened at the apex, emarginate and cavernous. Fruit protruding from the lower surface of the frond.

Riccia fluitans, Linn. Sp. Pl. 1606; Nees, Eur. Leberm. 4, p. 439; G. L. et N. Synop. Hepat. p. 610; Lindenberg, Monogr. Ricc., p. 443, t. 24-25; Rabenh. Hepat. Europ. exsic. n. 82, 296, 340; Engl. Bot. t. 251; Hooker et Taylor, Muscol. Brit. ed. 2, p. 213; Sullivant's Musci et Hepat. U.S. p. 684, tab. 6. Ricciella fluitans, Lindenb. Synop. Hepat. p. 115; Hübener, Hepat. Germ. p. 31; Dumort. Hepat. Europ. p. 171.

Hab. Stagnant pools and still places by river sides; generally floating among species of Lemna and other aquatics. Not unfrequent in ditches near the Shannon, Co. Limerick; by the side of the Bann River, above Drogheda; still ditches near Lough Neagh, where the canal joins the Lough at Lurgan.

RICCIOCARPUS, Corda.

Riccia, Linn. Syst. Nat. Ricciocarpus, Corda, in Opiz, Natur. p. 651 (1829). Hemiseuma, Bischoff, ex Nees, Europ. Leberm., 4, p. 419 (1838).

"Fruit immersed in the frond, and not protruding in either surface, at length bared by an incision in the central groove."—Dum.

Ricciocarpus natans, Corda. Frond inversely heart-shaped, grooved in the centre of upper surface, from ¼ to ¾ of an inch wide, clothed beneath and at the margin with long, purplish, pendent rootlets, which latter are fringed with slender cilia-like serratures.

Riccia natans, Linn. Syst. Nat. ed. v. 12, p. 2; Engl. Bot. t. 252; Weber, Prodr. Hepat. p. 117; Hook. et Taylor, Muscol. Brit. ed. 2, p. 214; Lindenb. Synop. Hep., p. 121; Mongr. Ricc., 475, t. 31–32; Nees, Eur. Leberm. 4, p. 419; G. L. et. N., Synop. Hep., p. 606; Rabenhor. Hep. Eur. exsic. n. 2, 140, 499; Sullivant's Musci et Hepat. U. S. p. 684, tab. 6. Ricciocarpus, Corda, in Opiz, Naturalientausch, p. 651 (1829); Dumort. Hepat. Europ. p. 172 (1874).

Hab. Stagnant pools and ditches. Rare in Ireland. Abundant in a large boggy pool about half-way between Drogheda and Navan, near the Railway, right-hand side going from Navan to Drogheda; ditch by the side of the Shannon, near Portumna, Co. Galway. Ditches near Passy, Co. Limerick, Dr. W. H. Harvey. This and the preceding species have been cultivated in Glasnevin Botanic Gardens, floated in pans of water, in which condition they multiply quickly and fruit freely.

Although I have followed Dumortier in his Hepaticæ Europæ in adopting the genera Ricciocarpus, Corda; and Ricciella, Al. Braun; yet the characters as given by these authors for separating them from Riccia, Linn., &c., seem to me too slight for constructing good genera on.

SECTION II. JUNGERMANNIACEÆ.

A. SCHIZOCARPÆ.

a. ANOMOGAMÆ.

"Prothallium disciform. Stems more or less regularly pinnate, more rarely dichotomously branched. Leaves incubous, conduplicate, the hinder lobe smallest—saccate, galeate, cucullate or flattish. Amphigastria mostly present, rarely wanting. Inflorescence diœcious, autœcious, more rarely parœcious. Perichætium apical, or from the posterior face of the stem, next its side above the axil of the leaves, as a proper branchlet, never from the axil of the amphigastrium. Colesule generally small, 5-plicate, and sometimes winged or compressed, rarely round or densely plicate, mouth often narrow and beak-shaped, rarely none. Setæ short or slender. Capsule minute, globose, mostly very thin and pellucid, as if composed of few strata, generally cleft to the middle, valves erect. Elaters 1- or 2-spired, adhering in pencil-like tufts to the apex of the valves or to the interior face of the capsule. Andrœcia lateral to the stem, like the perichætia. Antheridia two, or solitary, fixed in the axils of concave bracts, rarely in the axils of leaves or perichætial bracts."—Lindberg.

Sub-tribe 1. FRULLANIEÆ.

1. FRULLANIA, Raddi.

Jungermannia, Rupp. Fl. Jen. 1 ed., p. 346 (1718). Heimea, Neck. Elem. Bot. 3, p. 338 (1790). Jungermannia, Hooker, Brit. Jung. (1816). Frullania, Raddi, in Mem. Soc. Modena, 18, p. 20, tab. 2 (1818). Salviata, B. Gray, in Gray's Nat. Arr. Brit. Pl. p. 687 (1821). Jubula, Dumort. Comm. Bot. p. 112 (1823). Lejeunea, Corda, in Opiz, Beitr. 1, p. 652, n. 4 (1829).

Leaves incubous, distichous, lower segment saccate. Colesule compressed, trigonous, mouth constricted, mucronulate. Elaters with single spires.

a. JUBULOTYPUS, Dumortier.

1. *Frullania Hutchinsiæ* (Hook.), Nees. Autœcious. Stems cæspitose, prostrate, from one to two inches long. Leaves unequally 2-lobed, the lower lobe saccate, the upper ovate, spinulose-dentate at the margin. Amphigastria rounded at the base, acutely bifid, segments dentate. Colesule obcordate, slightly trigonal. Antheridia on short slender ramuli, proceeding from the inferior face of the stem.

Jungermannia Hutchinsiæ, Hook. Brit. Junger., tab. 1; Engl. Bot. tab. 2480. Salviata Hutchinsiæ, B. Gr. in Gray's Arr. Br. Pl. 1, p. 688. Jubula Hutchinsiæ, Dumort. Comm. p. 112; Syll. Jung., p. 36; Hepat. Europ., p. 26. Frullania Hutchinsiæ, Nees, Europ. Leberm. 3, p. 240; G. L. et N. Synop. Hepat., p. 426; Rabenhor. Hepat. Europ. exsic. n. 208, 477.

Hab. On wet rocks near waterfalls. Bantry, Miss Hutchins. Killarney, Cromaglaun, &c.; caves near the sea, Dingle Bay, Kerry. Ballinhassig glen, and near Kinsale, Cork, Isaac Carroll, Esq. Fissures of wet rocks by the lake near Letterfrack, Co. Galway (1874).

Var. β. integrifolia, Nees [Plate 45].

This appears to me a very distinct plant from the typical form of the species. It differs: 1, in the leaves being more obovate and less spinulose at their margins; 2, in the absence of an auricle to the margin of the leaf; 3, in the amphigastria being smaller, and the margins of their lobes more entire; 4, in the smaller size of the plant, and its olive-green colour.—The colesules are terminal on the main branches, and on their middle. They are trigonal as in the typical form. The andrœcium consists of small amenta, which proceed from the middle of the stem branches (autœcious). This remarkable plant was collected by Professor Lindberg and myself at Connor Hill, in July, 1873.

The few specimens I had were imperfect, and without colesules. In 1875 one of our garden assistants, Mr. D. Macardle, collected it in larger quantity in Maghanabo glen, near Castlegregory, Co. Kerry, growing over the fronds of Dumortiera irrigua. The plants he brought were more perfect, having both the gynœcium and andrœcium in good condition. I have carefully examined a number of these, and cannot find on any of them auricles to the leaves. On some, I have observed the slightest folding-in of a minute tooth-like portion, where the auricle ought to be. The amphigastria are minute, not more than half the size they are in the typical form. I have, however, no doubt that our plant is of the same kind as that noticed (G. L. et N. Synop. Hep. p. 426) as having been found in the island of Java by Blume; the note of observation by Dr. Gottsche, which is appended, having reference to his Java specimens, confirms me in this opinion. Professor Lindberg, in his paper on Hepaticæ collected in Ireland, states that this plant is found in North America and in the island of Java.

b. ASCOLOBIUM, Dumortier.

2. *Frullania dilatata* (Linn.), Dumort. Stems prostrate, in dense purplish patches. Leaves incubous, unequally 2-lobed, rotundate, entire, the lower lobe small, saccate. Amphigastria roundish, slightly notched at the apex. Colesule obcordate, tuberculated, angular on the under side.

Jungermannia dilatata, Linn. Sp. Pl. p. 1600; Hook. Brit. Jung. tab. 3; Tayl. in Fl. Hib. p. 2, p. 67; Lindb. Syst. Hepat., p. 17; De Notar. Prim. Hep. Ital., p. 10. Frullania minor, Raddi, Jung. in Mem. Modena, 18, p. 21, t. 2, fig. 3; Dumort. Rev. Jung. p. 13; Hep. Europ., p. 27; Nees, Europ. Leberm., 3, p. 217; G. L. et N. Synop. Hep., p. 415.

Hab. On the trunks of trees and on rocks. Very frequent in Ireland.

3. *Frullania fragilifolia*, Taylor. Stems from ¼ to ¾ of an inch long, growing in thin prostrate patches, of a deep brown colour. Leaves incubous, slightly raised in their centres, oblongo-rotundate, en-

tire, auricdelles oblong, helmet-like. Amphigastria ovate and bifid at the point, plane at the margin. Involucral bracts obtuse, with few teeth. Colesule obovate-cordate.

Frullania fragilifolia, Taylor, in Trans. Bot. Soc. Edin. 2, p. 43; G. L. et N. Synop. Hepat., p. 437; Spruce, Musc. et Hepat. Pyren. in Trans. Bot. Soc. Edin. 3, p. 215; Cooke's Brit. Hepat. p. 21, figs. 160, 161; Rabenh. Hep. Europ. exsic. n. 180, 200 et 226.

Hab. Shady rocks and trees. Not unfrequent in the Killarney woods. Dunkerron, Dr. Taylor. On boulders, Bantry Bay, Glengariff, Dr. Carrington.

4. ***Frullania tamarisci*** (Mich., L.), Dumort. Stems spreading in large patches, two to four inches long, of a brownish colour. Leaves incubous, closely and distichously arranged, unequally 2-lobed, the upper ovate-rotundate, the lower smaller and saccate. Amphigastria obscurely notched at the apex, subquadrate. Colesule ovate, smooth, triangular, attenuated, mouth dentate.

Jungermannia tamarisci, L. Sp. Pl. 1 ed., 2, p. 1134; Hook. Brit. Jung. t. 6; Taylor, in Fl. Hib., p. 68. Frullania major, Raddi, in Att. Soc. Sc. Modena, 18, p. 20. Salviatus, B. Gr. in Gray's Arr. Brit. Pl. 1, p. 687. Frullania tamarisci, Dumort. Rev. Jung., p. 13; Hepat. Europ., p. 28; G. L. et N. Synop. Hepat., p. 438. Var. β. microphylla, Gottsche, Rabenh. Hep. Europ. exsic. n. 209.

Hab. On the smooth bark of trees, Old Weir Bridge, Co. Kerry, Dr. Carrington.

5. ***Frullania germana***, Taylor. Stems procumbent, bipinnate, branches complanate, short-spreading. Leaves imbricated, ovate-roundish, entire, auricles oblong-ovate, ventricose. Amphigastria obovate, margins recurved, cleft at the apex. Involucral bracts entire. Colesule tubular, oblong-ovate.

Jungermannia germana, Taylor, in Trans. Bot. Soc. Edin., vol. 2, p. 43. Frullania germana, G. L. et N. Synop. Hepat., p. 450; Dumort. Hepat. Europ., p. 29. F. tamarisci, var. ϵ. germana, Carring. Irish Hepat. p. 457.

Plants of this species are generally larger, and of a lighter brown colour than those of F. tamarisci. The involucral bracts are entire. The leaves are destitute of the line of moniliform cells, which are so obvious in F. tamarisci, and the cells in them are larger, with the walls thicker.

Hab. On rocks and on trees. Frequent in the County of Kerry; Co. Donegal; Lough Bray, Wicklow.

Lejeunea, Libert.

Jungermannia, Mich. Nov. Pl. Gen., p. 9, t. 6, figs. 19, 20 (1729); Hooker, Brit. Junger. (1816). Lejeunea, Mademoiselle

Libert, in Ann. Gén. Sc. Phys. 6, p. 372, tab. 97 (1820). Pandulphinia, B. Gray, in Gray's Nat. Arr. Br. Pl., 1, p. 233 (1821). Marchesinius, B. Gray, *l. c.* p. 689. Phragmicoma, Dumort. Comm. Bot., p. 112 (1823). Colura, Dumort. Recueil, 1, p. 12 (1835).

Colesule obovate, angled or roundish, mouth contracted and dentate. Capsule 1-valved, deeply cleft, pedicels articulated. Elaters doubly spired, adhering to the apices of the segments of the capsules. Antheridia in axils of perichætial leaves.

LEJEUNEOTYPUS, Dumort. Lindb.

a. Leaves acuminate, or acute at their points.

1. *Lejeunea calyptrifolia* (Hook.), Dumort. Diœcious. Stems creeping, in very minute compact tufts. Leaves 2-lobed, the upper lobe large and peculiarly formed, resembling in no small degree the calyptra of some mosses, the lower obtusely quadrate, involute. Colesule lateral, oblong, flat campanulate, 5-toothed, and slightly contracted at the mouth. Antheridia from side of stem, not in axils of the leaves.

Jungermannia calyptrifolia, Hook. Brit. Jung., t. 43; Engl. Bot., 2538; Lindenb. Synop. Hepat., p. 24; Ekart, Synop. Jung. Germ., p. 59, t. 10, f. 86. Lejeunea calyptrifolia, Dumort. Comm. Bot., p. 111; G. L. et N. Synop. Hepat., p. 403; Cooke, Brit. Hepat., p. 21, fig. 156. Colura calyptrifolia, Dumort. Rev. Jung., p. 12; Hepat. Europ., p. 17.

Hab. On trees, stems of furze, heath, and rarely on bare rocks. Glengariff, Miss Hutchins. Near Dunkerron, Dr. Taylor, in Flora Hibernica. Torc Mountain, on the stems of pines, W. Wilson, and Dr. Carrington. On the bare rock at Connor Hill, Kerry, where it was observed in some quantity by Dr. Lindberg and myself, in July, 1873; also near the police barrack, Upper Lake, Killarney, on rocks, during same month.

2. *Lejeunea hamatifolia* (Hook.), Dumort. Autœcious. Stems very slender, minute, creeping and adhering closely to the surfaces on which they grow. Leaves unequally 2-lobed, the lower about half the size of the upper, the latter acuminated, incurved, coarsely serrated. Amphigastria small and bidentate. Colesule pentagonal, with crested ridges.

Jungermannia hamatifolia, Hook. Brit. Jung., t. 51; Engl. Bot., t. 2592; Lindenb. Synop. Hep., p. 23; Taylor, Fl. Hib., p. 2, p. 67. Lejeunea hamatifolia, Dumort. Comm. Bot., p. 111; Syll. Jung., p. 52, et Hepat. Europ., p. 20; G. L. et N. Synop. Hepat., p. 344; Rabenh. Hepat. Europ. exsic. n. 215–476.

Hab. On the trunks of trees, and on bare rocks. This species, which is so plentiful in the Killarney woods, is rare on the eastern coast and northern counties. I collected it at Glenarm, and

Collin Glen, Co. Antrim, in 1837; very fine and bearing capsules on trees in Glenfarn demesne, Co. Leitrim, 1875. Dr. Taylor observed it at Woodlands, near Dublin. At Powerscourt, Wicklow; on Connor Hill, Kerry, it grows on the bare rock, along with L. calyptrifolia, both of which were collected in company with Dr. Lindberg, July, 1873; Kylemore Castle demesne, Co. Galway, 1874. Near Cork, Isaac Carroll, Esq.

3. *Lejeunea echinata* (Hooker), Taylor. Autœcious. Stems hair-like, very minute. Leaves ovate, concave, acuminate, spinulose-dentate, saccate at the base. Colesule roundish, pentagonal. Antheridia singly or in pairs in axils of the perichætial leaves.

Jungermannia hamatifolia, β. echinata, Hook. Brit. Jung. 51. Lejeunea calcarea, Libert, Ann. Gén. Sc. Phys., 6, p. 373, t. 96, f. 1; Dumort. Syll. Jung., p. 33, t. 1, f. 3, et Hepat. Europ., p. 19; Nees, Europ. Leberm. 3, p. 293; G. L. et N. Synop. Hepat., p. 544; Rabenhor. Hep. Europ. exsic. n. 46, 283, 323; Cooke, Brit. Hepat., p. 20, fig. 150. Jungermannia echinata, Tayl. in Spruce's Musc. of Teesd., Trans. Bot. Soc. Edin. 2, p. 88.

Hab. On limestone rocks. Woodlands, Dublin, Dr. Taylor. Muckross demesne, Killarney, growing on the stems and leaves of Thamnium alopecurum, Dr. Carrington. In same situation and on same moss, Dr. Lindberg (1873.) Limestone rocks, near Tralee (1875).

4. *Lejeunea ovata*, Taylor. Diœcious. Stems creeping, branched. Leaves incubous, obliquely set on the branches, and close together, margins not serrated, bilobed, the larger lobe ovate-acute, saccate, and inflated. Amphigastria small, obcordate, notched at apex, segments obtuse. Colesule obovate, acute, and angled at the apex.

Jungermannia ovata, Dicks. Pl. Crypt. Brit. 3, p. 11, tab. 8, f. 6. Jungermannia serpyllifolia, β. ovata, Hook. Brit. Jung., n. 42. Lejeunea ovata, Taylor, in G. L. et N. Synop. Hep., p. 376; Spruce, Musc. et Hepat. Pyren. in Trans. Bot. Soc. Edin. 3, p. 212; Dumort. Hepat. Europ., p. 20.

Hab. On the moss-covered trunks of trees, and also on the bare bark. Very abundant at Cromaglaun, Kerry, and through all the Killarney district. Near Belfast, Dr. Dickie. More sparingly in the northern and eastern counties. Mr. Spruce has pointed out good distinguishing characters between this and L. hamatifolia in the work quoted.

b. Leaves obtusely rotundate.

5. *Lejeunea microscopica*, Taylor. Parœcious. Plant very minute, and stain-like. Leaves ovate-lanceolate, concave, acute, bluntly dentate at the margin, patent. Colesule obovate, contracted at the mouth, subdenticulate.

Jungermannia microscopica, Taylor, in Fl. Hib. 2, p. 59; Hook. Journal of Botany, 4, p. 97, t. 20; Nees, Europ. Leberm. 3, suppl., p. 566. Lejeunea microscopica, Taylor, in G. L. et N. Synop. Hepat., p. 345; Carrington, in Trans. Bot. Soc. Edin. 7, p. 3, p. 456; Cooke, Brit. Jung., p. 20, fig. 151; Dumort. Hepat. Europ., p. 19.

Hab. Parasitic on mosses, ferns, and dead stumps of trees. Cromaglaun, Kerry, Dr. Taylor and Dr. Carrington. On Trichomanes radicans, Purple Mountain, Killarney; glen at Brandon Mountain, &c. This very minute plant appears like a slight green stain on the plants on which it grows, and is of frequent occurrence, though often overlooked. It has not, however, we believe, been observed hitherto out of the County of Kerry. To the unaided eye it has no appearance of an organised plant, but it is easily detected when placed under the microscope, and moisture applied. The minute stems float and spread themselves and so do the leaves. It is one of the most distinct species, and cannot be mistaken or confounded with any of the others.

6. *Lejeunea inconspicua* (Mich., Raddi), De Notaris. Autœcious. Stems very minute, hair-like. Leaves distant, ovate-rotundate, entire, convex. Amphigastria none. Colesule axillary, turban-shaped, pentagonal and plicate.

Jungermannia inconspicua, Raddi, in Att. Soc. Modena, 18, p. 34, t. 5, fig. 2. Jungermannia minutissima, Taylor, in Trans. Bot. Soc. Edin. Lejeunea Taylori, Spruce, in Trans. Bot. Edin. vol. 3, p. 12. Lejeunea minutissima, G. L. et N. Synop. Hep. p. 387; Dumort. Hepat. Europ., p. 18.

Hab. On stems of heath and furze, also on trunks of trees. Near Kenmare, Dr. Taylor; and other parts throughout the counties of Kerry and Cork. Not very rare, but chiefly confined to the southern counties. This minute plant, which can only be well distinguished from Lejeunea minutissima, Smith, by wanting amphigastria, was mixed up with that species, until Dr. Taylor published characters for each, and separated them. Dr. Spruce has, however, shown that Dr. Taylor was in error, in supposing the exstipulaceous plant to be Smith's plant. See foot-note in Trans. Bot. Soc. Edin. vol. iii., p. 212.

7. *Lejeunea minutissima* (Smith), Dumortier. Diœcious. Stem creeping, capilliform. Leaves indistinctly 2-lobed, lower lobe minute, rather distantly placed on the stem, ovate-obtuse. Amphigastria bifid. Colesule lateral, obovate-rotundate, pentagonal and contracted at the mouth.

Jungermannia minutissima, Smith, Engl. Bot. t. 1633; Hook., Brit. Junger. t. 52. Jungermannia ulicina, Taylor, in Trans. Bot. Soc. Edin. 1, p. 115. Lejeunea minutissima, Dumort. Syll. Jung. p. 33, et Hepat. Europ. p. 19; Taylor, in G. L. et N. Synop. Hep. p. 387; Rabenhor. Hep. Europ. exsic. n. 322; Cooke, Brit. Jung. p. 20, fig. 155.

Hab. On the stems of trees and on mosses. Abundant in the Killarney woods, and other parts of Kerry and Cork; Kylemore Castle, Co. Galway; Collin Glen, Belfast; Woodlands, Dublin; Luggielaw, and Powerscourt, Wicklow; Glenfarn demesne, Co. Leitrim.

8. *Lejeunea serpyllifolia* (Mich., Dicks.), Libert. Autœcious. Stems prostrate or creeping, pinnately branched. Leaves incubous, 2-lobed, lobes unequal, the upper being much the largest and of a roundish-oblong form, the lower much smaller, and involute. Amphigastria wide, roundish, deeply bifid. Colesule somewhat pear-shaped or obovate, mouth angled and protruding.

Jungermannia serpyllifolia, Dicks. Pl. Crypt. Brit. 4, p. 19; Engl. Bot. t. 2537 (excl. synon.); Hook. Brit. Jung. t. 42; Lindenb. Hep. Europ. p. 21. Lejeunea serpyllifolia, Lib. in Ann. Gén. Sc. Phys. 6, p. 374; Dumort. Comm. Bot. p. 3; Syll. Jung. Eur. p. 33, et Hepat. Europ. p. 21; G. L. et N. Synop. Hepat. p. 374; Rabenhor. Hep. Eur. exsic. n. 435.

Hab. On trunks of trees covered with the larger mosses, &c., and on damp banks among mosses. Generally distributed through Ireland.

Var. β. thymifolia, Carrington, in Trans. Bot. Soc. Edin. 7, p. 456. "Leaves larger, elliptic-ovate, very convex, closely imbricated, inflexed."

Var. γ. heterophylla, Carrington. "Branches attenuate, microphyllous. Leaves plane, lobule obsolete, variously shaped, distant, chlorophyllose.

Hab. On wet shady rocks. O'Sullivan's cascade, and near Torc Waterfall, Dr. Carrington.

Var. β. cavifolia (Ehrh.), Lindb. "Leaves crowded, front lobe convex, incumbent when dry, more spreading from the basal sac, generally much decurved, oblique, broadly ovate, very blunt, yet sometimes narrowed distinctly at apex, never pointed, very entire, basal lobe 3–5 times smaller, cells very full of chlorophyll and thickened, trigonal spaces distinct. Amphigastria subadpressed, equally large or larger than the hinder lobe, convex, otherwise as in type. Colesule more prominent, rising from a narrow base, oval pyriform, the upper 4th part 5-plicate, the rest as in type."—Lindberg.

Hab. Glena, Killarney, on mosses, and on the stems of trees. Torc Cascade, among Hypnum eugyrium, 1873, Dr. Lindberg. Dr. Lindberg states that this form is the common form in Scandinavia, where the typical form is much rarer.

9. *Lejeunea patens*, Lindberg [Plate 43].

Autœcious. "Shorter and twice as narrow as last species, pale, very transparent, shining when dry, usually more branched and interwoven, remarkably convex, or nearly roundish. Leaves more or less crowded, the front lobe very convex when dry, also overlying, rising abruptly at a nearly right angle from the basilar lobe, very much decurved and well overlapping the stem—['maxime decurvus, intus caulem valde superans,'] oblique, broadly oval-elliptic, or very bluntly oval. Cellules very smooth, scarcely or not at all chlorophylliferous, much thickened, with the trigonal spaces very distinct. Amphigastria wide, two or three times as short as the hinder lobe, very convex, subrotund and cleft in the middle, sinus more or less obtuse, with bluntish segments, everywhere indented with projecting cells. Colesule always on the lateral branches, slightly projecting, pyriform-clavate, rounded below, enfolding, the upper 4th part 5-plicate, with prominent and more flattened crests, crenulate at apex."—Lindberg.

Lejeunea patens, Lindberg, Acta Soc. Sci. Fenn. x. p. 482 (read 1874, pub. 1875). L. serpyllifolia, var. γ. ovata, Nees, Nat. Eur. Leb. 3, p. 264 (1838).

Hab. Co. Kerry, "Connor Hill, supra oppidulum Dingle, ad Pleuroziam terra turfosa humida (coles) et ad muscos varios in rupibus sicciusculis; Ventry ad Dingle Bay; Killarney, O'Sullivan's Cascade; 'Supra emortuum Thamnium alopecurum, Glena et Torc Cascade.' Killarney, Torc Cascade, Dr. Carrington (1861). Co. Sligo, Benbulben (Dr. Moore)." Glenad, Co. Leitrim, 1875.

10. *Lejeunea Moorei*, Lindberg [Plate 44].

Autœcious. "Rather rigid, yellowish or very green, always opaque and not pellucid, almost unbranched, and not radiculose. Leaves, front lobe imbricated, hardly or very little overlapping the stem—['intus caulem vix vel parum superans']—oblique, ovate-elliptic, roundly-obtuse, quite entire, the lower margin at apex of stem recurved when dry, basilar sac and hinder lobe very small. Cellules covered with minute papillæ, closely packed with chlorophyll, slightly thickened. Amphigastria imbricated, 4–6 times larger than the hinder lobe, distinctly cordate at the base, not decurrent, ovately-oval, very entire, cleft in the centre by a narrow and acute sinus, the segments obtuse. Perichætia on the stem itself, and on innovations from the apex of it."—Lindberg.

["Jungermannia flava, Sw. Prodr. Fl. Ind.-Occ. p. 144, et Fl. Ind.-Occ. 3, p. 1859; Schwaegr. Hist. Musc. Hep. Prodr. p. 16, n. 17; Weber (F.), Hist. Musc. Hep. Prodr. p. 29, n. 15; Sprengel (L.), Syst. Veg., 16 ed. 4, p. 1, p. 223, n. 74. Lejeunea flava, Nees, Nat. Eur. Leb. 3, p. 277, in obs. 2, G. L. et N. Synop. Hepat. p. 373, n. 157; Gottsche, Mex. Lev. p. 219, n. 46."]? L. Moorei, Lindb. Act. Soc. Sci. Fenn. x. p. 487.

Hab. "Co. Kerry: Killarney, Glena et Cromaglaun, locis umbrosis silvarum, ad truncos arborum vetustarum, et supra Isopterygium elegans in fissuris rupium."—Lindb. Glen at the Hunting Tower, Cromaglaun, 1862; O'Sullivan's Cascade, 1875.

11. *Lejeunea Mackaii* (Hooker), Sprengel. Autœcious. Stem creeping. Leaves distichous, unequally 2-lobed, the upper lobe large and round, the lower small and involute. Amphigastria obcordate, roundish, wider than the stem. Colesule compressed, gibbous below, mouth contracted, toothed. Male branches proceeding from side of stem, not in axils of the leaves, but directly under the leaf next above.

Jungermannia Mackaii, Hook. Brit. Jung. t. 53; Engl. Bot. t. 2573; Lindb. Hepat. Europ. p. 20; Ekart, Syn. Jung. p. 59, t. 10, fig. 72. Phragmicoma Mackaii, Dumort. Comm. Bot. p. 112; Syll. Jung. p. 35, et Hepat. Europ. p. 30; Nees, Europ. Leberm., 3, p. 249; G. L. et N. Synop. Hep. p. 293; Rabenhor. Hep. Europ. exsic. n. 81, 164, 206. Marchesinia Mackayi, B. Gr. in Gray's Arr. Brit. Pl. 1, p. 689. Lejeunea Mackaii, Sprengel, Syst. Vegt. ed. 16, p. 1, p. 233; Lindberg, Hepat. Scand. exsic., fasc. 1.

Hab. Limestone rocks principally. Frequent in the south and west of Ireland, rarer in the north and east. Very large and fine at Muckross, Killarney, and by the side of a lake near Letterfrack, Galway; Woodlands, Dublin; near Cork, frequent. The stems are sometimes quite black, when creeping over the nearly perpendicular faces of rocks.

Radula, Dumortier.

Jungermannia, Rupp. Fl. Jen., 1 ed. p. 345 (1718); Hooker, Brit. Jung. (1816); Martinellia, sect. *a*, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 690 (1821). Radula, Dumort. Comm. Bot. p. 112 (1823), et Recueil, 1, p. 14 (1835); Nees, Nat. Eur. Leberm. 1, p. 96 (1833). Jubula, Corda, in Sturm, Deutschl. Fl. 2, fasc. 26 et 27, p. 152 (1835).

1. *Radula Xalapensis*, N. M. (1836). Diœcious. Stems procumbent, pinnately branched. Leaves incubous, orbicular, obtuse, entire, upper lobe large and broad, undulate and somewhat cordate at base.

Radula Xalapensis, N. M., in Ann. Sc. Nat. 2 series, 5, p. 56; Lindb. Hepaticæ in Hibernia lectæ (1875). Radula voluta, Taylor, in G. L. et N. Synop. Hep. p. 253 (1845); Cooke's Brit. Hepat. p. 18, fig. 136; Dumort. Hepat. Europ. p. 32.

Hab. On wet rocks near streams. Dunkerron, Dr. Taylor. On boulders by the side of the stream below Torc Waterfall, Killarney, Dr. Carrington. Rocks below the Eagle's Nest, Cromaglaun, George E. Hunt. Near Derrycunighy Cascade, and at Gortagre. Dr. Lindberg states that he can find no great distinction between the Killarney plant and specimens of R. Xalapensis, which he possesses, from New Granada, collected by Lindig, and from Tallulah Falls, Georgia, U. S.

2. ***Radula aquilegia***, Taylor. Diœcious. Stems cæspitose, compressed. Leaves distichous, convex on the upper surface, entire, obovate-roundish, unequally 2-lobed, the lower lobe closely adpressed.

Jungermannia complanata, β. minor, Hook. Brit. Junger. t. 81, fig. 17. J. aquilegia, Taylor, in Trans. Bot. Soc. of Edinb. 2, p. 117. Radula aquilegia, Taylor, in G. L. et N. Synop. Hepat. p. 260; Cooke's Brit. Hepat. p. 19, figs. 139, 140; Dumort. Hepat. Europ. p. 32.

Hab. On rocks and trees. Not rare in the Killarney district.

3. ***Radula complanata*** (Linn.), Dumortier. Stems creeping, complanate. Leaves distichous, imbricated, unequally 2-lobed, upper lobe large, and nearly round, lower lobe much smaller and adpressed. Colesule terminal, oblong, compressed, truncate.

Jungermannia complanata, Linn. Sp. Pl.; Hook. Brit. Jung. t. 81; Engl. Bot. t. 2499. Candollea complanata, Raddi, Jung. Etr. in Mem. Modena, XI. Radula complanata, Dumort. Comm. Bot. p. 112; Syll. Jung. p. 38; Hepat. Europ. p. 32; G. L. et N. Synop. Hep. p. 257; Rabenh. Hep. Europ. exsic. n. 17–361.

Hab. On trees and rocks. Very common in every part of Ireland. Varying considerably in size and general appearance in different localities, and under peculiar circumstances.

PORELLA, Dillenius.

Jungermannia, Rupp. Fl. Jen. 1 ed., p. 345 (1718). Porella, Dill. Hist. Musc. p. 459, tab. 68 (1741); Linn. in Act. Ups. 1741, p. 83 (1746); Lindb. in Act. Soc. Sc. Fenn. IX., 329–345 (1869). Cavendishia, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 689 (1821). Madotheca, Dumort. Comm. Bot. p. 111 (1823). Lejeunea, Corda, in Opiz, Beitr. 1, p. 652 (1829).

Colesule lateral, compressed. Capsule nearly sessile, univalved, 4-cleft. Elaters with two spires. Antheridia in the saccate bases of the perigonial leaves.

1. ***Porella lævigata*** (Rupp., Schrad.), Lindberg. Diœcious. Stems prostrate, bipinnately branched, from 2–4 inches long. Leaves incubous, broadly ovate, dentate, unequally 2-lobed, the smaller lobe closely pressed against the base of the larger lobe. Amphigastria quadrate, spinulose-dentate. Colesule dentate.

Jungermannia lævigata, Schrader's Sammlung, n. 104; Hook. Brit. Jung. tab. 35; Lindenb. Synop. Hepat. p. 18. Madotheca lævigata, Dumort. Comm. Bot. p. 111; Syll. Jung. p. 34, et Hepat.

Europ. p. 22; G. L. et N. Synop. Hepat. p. 276. Cavendishia lævigata, B. Gray, in Gray's Arr. Brit. Pl. 1, p. 690. Porella lævigata, Lindberg, in Act. Soc. Sc. Fenn. IX., p. 335.

Hab. Near Bantry, Miss Hutchins. Near Cork, Isaac Carroll. Lough Bray, Wicklow.

Var. β. *integra* (Dill.), Lindberg. Killarney, Glena, on inundated stones by the margin of the lower lake, Dr. Lindberg (1873).

2. *Porella platyphylla* (L.), Lindberg. Stems irregularly pinnate, branches nearly of equal length, sometimes crowded at the apex, where they are obtuse. Leaves incubous, raised at their upper margin, which is curved and undulated, more or less concave at the base, and decurved at the apex, mostly entire at the margin, lobule suboblique, ovate-obtuse, or indistinctly a little acute. Amphigastria adpressed to the stem, oblong-ovate or ligulate, slightly recurved at apex. Antheridia in the axillæ of the perigonial leaves.

Jungermannia platyphylla, L. Sp. Pl. 1 ed., p. 1134; Wahlenb. Fl. Lapp. p. 388, n. 704; Hook. Brit. Jung. t. 40, fig. 1; Hartm. Skand. Fl., 1 ed., p. 435. Cavendishia platyphylla, Gray's Nat. Arr. Brit. Pl. 2, p. 690; Carruth. in Seemann's Journal Bot. 3, p. 301. Madotheca platyphylla, Dumort. Comm. Bot. p. 111, et Syll. Jung. Eur. p. 31; G. L. et N. Synop. Hep. p. 278, n. 30.

Hab. On rocks and stones generally, but also on trees and moss-covered banks. Frequent in many parts of Ireland.

3. *Porella Thuja*, Dicks. Stems tufted, branched subpinnately, convex and smooth above. Leaves closely imbricated, lobed, lower lobe spreading, entire recurved, anterior ovate-obtuse, margin reflexed. Amphigastria oblong, acute, entire, margin reflexed, apex recurved. Involucral bracts for the most part ciliate-serrate. "Tufts wide, olive-green; the older parts purplish brown, shining, the shoots acuminated."—Taylor.

Lichenastrum Arboris Vitæ facie, foliis rotundioribus, Dill. Hist. Musc. p. 502, tab. 72, fig. 33. Jungermannia Thuja, Dicks. Pl. Crypt. 4, p. 19; Taylor, in Trans. Bot. Soc. Edin. 2, p. 116; Hook. Brit. Jung. t. 40, nn. 3-4. Var. β. major et var. γ. Thuja. Madotheca Thuja, Dumort. Comm. Bot. p. 111; Syll. Jung. p. 31, et Hepat. Europ. p. 24.

Hab. On rocks and stones. Bantry, Miss Hutchins. Near Lough Finnehy, Dunkerron, Co. Kerry, Dr. Taylor. Lough Bray, Co. Wicklow; Brandon, Co. Kerry (1864).

4. *Porella Cordæana*, Dumortier. "Stems bi-tripinnate. Leaves ovate entire, attached obliquely to stem, auricles oblique, ovate, slightly acute. Amphigastria subrotund, entire. Colesule bilabiate, subcrenate."—Dum.

"Jungermannia Cordæana, Hüben. Hep. Germ. p. 291; De Not. Prim. Hep. Ital. p. 10; Mougeot et Nestl. Crypt. Vog. n. 1044. Madotheca Cordæana, Dumort. Rev. Jung. 1, p. 11. Lejeunea Cordæana, Nees et Mont., in Ann. Sc. Nat. 1836, p. 7. Madotheca porella, Nees, Eur. Leberm. 3, p. 201; G. L. et N. Synop. Hepat. p. 281."—Dumort. Hepat. Europ. p. 25 (1874). Cavendishia rivularis, Carruth. in Seem. Journ. Bot. 3, p. 301. Porella dentata, Hartm. Lindb. in Acta Societatis Scientiarum Fennicæ, x.

Hab. On wet stones, near rivulets, &c. Near Fermoy, Co. Cork, T. Chandlee. The only Irish specimens I have seen are those collected by T. Chandlee in the locality quoted. They were named Madotheca rivularis when sent to me, and Professor Lindberg, who examined them in my herbarium, referred them with certainty to Madotheca porella, Nees.

5. *Porella pinnata*, L. Stems irregularly pinnate, or subdichotomously branched. Leaves slightly adpressed, ovate-oblong, plane or indistinctly decurved at the apex, margin quite entire, lobule minute, plane, not decurved, spreading from the stem. Amphigastria adpressed to the stem, slightly decurrent, obtuse-rotundate.

Porella pinnata, L. Sp. Pl. 1 ed., 2, p. 1106. Jungermannia porella, Dicks. in Trans. L. Soc. 3, p. 239; Schwægr. in Linnæa, 13, p. 114. Jung. Cordæ, Hüben. Hep. Germ. p. 291. Madotheca porella, Nees, Natur. Eur. Leberm. 3, p. 201, n. 6; G. L. et N. Synop. Hep. p. 281, n. 35.

Hab. Near Fermoy, Co. Cork, T. Chandlee, Esq. Connor Hill, Co. Kerry, Dr. Lindberg (1873). The only Irish specimens I have seen of this plant are those from T. Chandlee, which were sent to me under the name of Madotheca rivularis, but referred unhesitatingly to Madotheca porella, Nees, by Dr. Lindberg. Notwithstanding the labour bestowed on the genus Porella by Dr. Lindberg (Acta Societatis Scientiarum Fennicae, tom. IX., 1869), I cannot make out clearly the species he refers P. rivularis to. He quotes some of the same authors, namely, Nees, Hübener, and Carruthers' works, same page and same number to species, as synonyms of his Porella dentata, n. 5, and of his Porella pinnata, n. 6. Not having any specimens of Taylor's Jungermannia rivularis (Trans. Bot. Soc. Edin. 2, p. 16), I am unable to refer it to either of these. Dr. Carrington notices among his Irish Hepaticæ (Trans. Bot. Soc. Edin. 7, p. 455), Madotheca porella, Nees, as having been sent to Dr. Gottsche by Dr. Taylor from south of Ireland; but to which of Lindberg's species is it referable?

Sub-tribe 2. PLEUROZIEÆ.

PLEUROZIA, Dumortier.

Jungermannia, Weiss, Pl. Crypt. Fl. Gott. p. 123 (1770); Sm. Engl. Bot. tab. 2500 (1813); Hook. Brit. Jung. (1816); Hüben. Hep.

Germ. p. 275 (1834). Pleurozia, Dum. Recueil, 1, p. 15 (1835). Physiotium, Nees, Nat. Eur. Leberm. 3, pp. 6 et 75 (1838).

Involucral bracts deeply bilobed. Colesule cylindrical, much exserted, mouth denticulate, teeth slightly decurved at apex.

Pleurozia cochleariformis, Dumortier. Stems long, varying from 1 to 5–6 inches, ascending. Leaves closely imbricated, unequally 2–lobed, upper lobe larger, concave, bifid, and serrated at the apex, lower lobe pouch-like, and much smaller, colour dark brown, inclining to purple.

Jungermannia cochleariformis, Weiss, Pl. Crypt. p. 123; Hook. Brit. Junger. tab. 68. Pleurozia cochleariformis, Dumort. Rev. Jung. p. 15; Hepat. Europ. p. 52. Physiotium cochleariformis, Nees, Europ. Leberm. 3, p. 79; G. L. et N. Synop. Hepat. p. 235.

Hab. On wet bogs and moors. This is probably the most beautiful to the unaided eye among all the British or Irish species. Where it grows freely on wide-spread moors, or in damp situations in the more mountainous parts of the country, the pretty purplish stems can be detected at a considerable distance from the spot where they grow. It ranges from the northern to the southern counties, and from the eastern to the western, and is especially abundant in the latter.

b. Homogamæ.

"Stem irregularly branched, with branches from the amphigastrial axil, or with innovations more or less approximate to the colesule, rarely dichotomous, pinnate or bipinnate. Leaves succubous or incubous, sometimes opposite or connate, rarely conduplicate and then almost always the front lobe is smaller, so as to form very variable, round or reniform to sublinear, quite entire to broken up in filiform segments. Amphigastria narrow, more or less ovate-lanceolate, rarely round, quite entire to broken up into filiform segments, sometimes wanting. Gamœcium diœcious, parœcious, more rarely autœcious. Perichætium proceeding from the amphigastrial axilla as proper branches, either apical on the stem and its innovations, or in many frondose forms placed on the inner face, more or less below the apex of the stem, sometimes saccate and dependent from the stem. Colesule usually large, from 3–5 plicate, very rarely winged, sometimes complanate or compressed, occasionally round or densely plicate, very rarely winged, with the mouth more or less wide, hardly ever beak-shaped. Seta long or very long, sometimes thickish. Capsule large, globose-cylindric, of thick texture, brown and not pellucid, as if formed of at least two strata, valves cleft to the base, patent or divaricate, for the most part shewing spiral fibres internally. Elaters two-, rarely one-, tri-, or quadri-spiral, adhering to the inner face of capsule, very rarely to apex of valves, or free. Spores minute or rather large, sometimes appendiculate externally. Andrœcia proceeding from the amphigastrial axils as perichætia, or antheridia, generally two, rarely more, or singly in the axils of the uppermost leaves, or in the frondose forms, fixed over the anterior face of the stem or immersed in it, the foot-stalk straight, hardly ever arcuately curved. Paraphyses sometimes present, usually filiform."—Lindberg.

Subsection †. OPISTHOGAMÆ.

"Stem irregularly branched by bifurcation at the apex, or with branches from the amphigastrial axils, sometimes pinnate or decompound. Leaves incubous or succubous, very rarely conduplicate, entire or lobed. Amphigastria present, at least in the perichætium of all, very like the leaves, or more or less ovate, undivided or lobed. Gamœcium diœcious, autœcious, rarely parœcious. Female branch proceeding from the amphigastrial axillæ, almost always short. Colesule triangular, very rarely round, compressed or wanting. Antheridia on a proper branch, proceeding from the amphigastrial axil, hardly ever placed in the foliar axillæ of the stem itself. Paraphyses none."—Lindberg.

Sub-tribe 3. LEPIDOZIEÆ.

LEPIDOZIA (Linn.), Dumortier.

Jungermannia, L. Sp. Pl. 1, ed. 2, p. 1833 (1758); Hook. Brit. Junger. (1816). Blepharostoma, Dumort. Syll. Jung. Eur. p. 65 (1831). Pleuroschisma, sect. 2, Lepidozia, Dumort. Syll. Jung. Eur. Mastigophora, Nees, Nat. Eur. Leber. 1, p. 95 (1833). Lepidozia, Dumort. Recueil, 1, p. 19 (1835); G. L. et N., Synop. Hepat. p. 200 (1845).

Involucre polyphyllous, imbricated on every side, scale-like and denticulate at the apex. Colesule cylindrical, sulcate, denticulate at the mouth, peduncle not articulate.

1. *Lepidozia reptans* (Linn.), Dumortier. Stems cæspitose, creeping, and irregularly branched, varying from one to two inches in length, flagilliferous. Leaves incubous, decurved, sub-quadrate, acutely 3-4 toothed. Amphigastria wider than the stem, quadrate, quadridentate. Colesule dorsal.

Jungermannia reptans, Linn. Sp. Pl., 1599; Hook. Brit. Jung., t. 75; Engl. Bot. t. 608; Lindenb. Synop. Hepat., p. 44; De Notar. Prim. Hepat. Ital. p. 21. Lepidozia reptans, Dumort. Rev. Jung. p. 19, et Hepat. Europ. p. 109; G. L. et N. Synop. Hepat. p. 205; Rabenhor. Hepat. Europ. exsic., 282–479. Mastigophora reptans, Nees, Leber. Europ. 3, p. 31.

Hab. Woods and bushy banks. This beautiful plant occurs in more or less abundance in every county in Ireland.

2. *Lepidozia cupressina* (Sw.), Dum. Stems suberect, densely packed together and closely pinnate. Leaves subcordate, oblique, quadrifid

at the points, the lower tooth incurved. Amphigastria quadrifid, broader than the stem.

Jungermannia reptans, β. pinnata, Hook. Brit. Jung., t. 75. Lepidozia pinnata, Dumort. Rev. Jung., p. 19. Lepidozia tumidula, Taylor, in G. L. et N. Synop. Hepat., p. 206. Lepidozia cupressina, Lindberg, Carring. Irish Hepat., Trans. Bot. Soc. Edin. 7, p. 453, tab. 2, fig. xi.

Hab. On the ledges of damp rocks and on banks. Very abundant in the Killarney woods. In the larger size and general appearance of this plant, it shows a difference compared with the former species. It varies, however, so much in these respects, according to the habitats where it grows, that it is not easy to separate them distinctly. The form and size of the areolæ are, however, different, as pointed out by Dr. Carrington, and the incurved central tooth of the leaves is constant in the latter. Dr. Lindberg, who has of late years studied the Hepaticæ so carefully, considers the Irish plant to be specifically identical with the American L. cupressina, in which respect Dr. Carrington agrees.

BAZZANIA, Bennett, Gray.

Jungermannia, L. Fl. Suec. 1 ed., p. 335, excl. Synon. Micheli (1753); Hook. emend. Brit. Jung. (1816). Bazzania, B. Gr. in Gray's Nat. Arr. Brit. Pl. 1, p. 704 (1821). Pleuroschisma, sect. 3, Pleuroschismotypus, Dum. Syll. Jung. Europ. p. 70 (1831). Herpetium, Nees, Nat. Eur. Leber. 1, p. 96 (1833). Mastigobryum, G. L. et N. Synop. Hepat., p. 214 (1845).

Involucre polyphyllous, bracts scale-like, imbricated on each side. Colesule dorsal, subacuminate, compressed at the mouth, peduncles inarticulated.

1. *Bazzania trilobata* (Mich., L.), B. Gr. Stems creeping, branched, with flagellæ. Leaves incubous, ovate, concave, narrowed towards the points, which are tridentate. Amphigastria broad and quadrate, as wide or wider than the stem. Colesule dorsal, slit on one side, mouth entire.

Jungermannia trilobata, Linn. Sp. Pl. 1599; Hook. Brit. Jung. t. 76; De Notar. Hepat. Ital. p. 20; Taylor, in Fl. Hib. p. 65. Jungermannia radicans, Hoff. Germ. 2, p. 87; Engl. Bot. t. 2232. Pleuroschisma trilobata, Dumort. Syll. Jung. Eur. p. 70, n. 96, et Hepat. Europ. p. 103. Mastigobryum trilobatum, G. L. et N. Synop. Hepat. p. 230.

Hab. Mountain woods, and rocky places, in many parts of the country. Sleemish Mountain, Co. Antrim; Dart Mountain, Co. Derry. More abundant in the south, especially in the Killarney woods. About Kylemore, Co. Galway.

2. *Bazzania triangularis*, Schleich. Stems small, decumbent, fragile. Leaves incubous, ovoid, convex, tri-crenate at the narrow apex. Amphigastria roundish-ovate, broader than the stem, and notched at the apex.

Jungermannia triangularis, Schleich. Pl. Crypt. Helv. 2, n. 61. J. tricrenata, Wahlenb. Fl. Crypt. p. 364; Lindenb. Synop. Hepat. p. 43; Ekart, Syn. Jung. p. 49, t. 12, fig. 99; De Notar. Prim. Hepat. Ital. p. 20. J. deflexa, Mart. Fl. Crypt. Erlang. p. 135, t. 3, fig. 8. Bazzania trilobata, var. β. minor, B. Gr. in Gray's Arrang. Br. Pl. 1, p. 704. Pleuroschisma deflexum, Dumort. Syll. Jung. p. 71, et Hepat. Europ. p. 105.

Hab. Bushy places and woods. Frequent about Torc Mountain, Cromagloun, and other places near Killarney, Dr. Carrington. O'Sullivan's cascade, and Brandon Mountain, Kerry. Glenbower wood, near Fermoy, Isaac Carroll, Esq. Glenarrif, Co. Leitrim. On the high limestone range of Benbulben, Co. Sligo, not unfrequent.

ODONTOSCHISMA, Dumortier.

Jungermannia, Dicks. Fasc. Pl. Crypt. Brit. 1, p. 6, tab. 1, fig. 10 (1785); Hooker, Brit. Jung. (1816). Martinellia, sect. *b*, B. Gr. in Gray's Arr. Brit. Pl. 1, p. 693 (1821). Odontoschisma, Dum. Recueil, 1, p. 19, n. 25 (1835). Sphagnocetis, Nees, in G. L. et N. Synop. Hepat. p. 148 (1845). Gymnanthe, Mitten, in Jour. Linn. Soc. 7, p. 166 (1863).

Involucre polyphyllous, bracts in several rows, imbricated, bilobed. Colesule cylindrical, cleft at one side, denticulate at the mouth, originating from the under side of the branch, and shortly pedunculate.

1. *Odontoschisma sphagni* (Dicks.), Dumortier. Diœcious. Stem ascending singly or in small patches among mosses. Leaves close, succubous, orbicular, secund. Amphigastria small, lanceolate, and only on the young shoots. Colesule terminal, upon a short proper branch, originating from the ventral side of the stem, oblong, wider in the middle, the mouth denticulate.

Jungermannia sphagni, Dicks. Fasc. Pl. Crypt. Brit. 1, p. 6; Engl. Bot. t. 2470; Hook. Brit. Jung. t. 33; Lindenb. Synop. Hep. p. 28; Taylor, in Fl. Hib. 2, p. 58. Odontoschisma sphagni, Dumort. Rev. Jung. p. 19, et Hepat. Europ. p. 108. Sphagnocetis communis, Nees, in G. L. et N. Synop. Hepat. p. 148; Rabenhor. Hep. Europ. exsic. n. 300–566, 440.

Hab. In bogs among Sphagnum. Frequent in most parts of Ireland, but more abundant in the south than elsewhere.

2. *Odontoschisma denudatum* (Nees), Dumort. Diœcious. Stem procumbent, branched, branches with flagellæ, ascending and leafless near the points, tipped with gonidiferous gemmæ. Leaves small

at the base, or none, increasing in size towards the middle of the stem, and decreasing from the middle to the apex, succubous, secund, roundish-ovate, with the points sometimes slightly emarginate. Amphigastria larger and more readily observed than they are in the former species, confined to the younger branches. Colesule cylindrical, fringed at the mouth.

Jungermannia denudata, Nees, in Mart. Fl. Crypt. Erlang. p. 14; Lindenb. Synop. Hepat. Europ. p. 71, n. 69; Hartm. Skand. Fl. 3 ed. p. 319. Odontoschisma denudatum, Dumort. Recueil, 1, p. 19; et Hepat. Europ. p. 108. Jungermannia sphagni, Hook. Brit. Jung. suppl. t. 3; Ekart, Synop. Jung. Germ. t. 6, f. 48. Sphagnoecetis communis, β. macrior, Nees, in G. L. et N. Synop. Hep. p. 149.

Hab. On rotten trunks of trees, and in wet places in shady woods. On the side of Corslieve Mountain, near Bangore, Co. Mayo (1859).

CEPHALOZIA, Dumortier.

Jungermannia, Mich. Nov. Pl. Gen. p. 9, no. 5, tab. 6, fig. 17 (1729); Hook. Brit. Jung. (1816). Cephalozia, Dumort. Recueil, 1, p. 18, n. 21 (1835). Zoopsis, Hooker, in Tayl. Crypt. Fl. Antarct. p. 55 (1845). Trigonanthus, Spruce, in Trans. Bot. Soc. Edinb. 3, p. 207 (1849).

"Involucre polyphyllous, gemmiform, bracteolæ deeply lacerated, imbricated in several rows all round the stem and base of the colesule, exterior, stipuliform. Colesule sessile, erect, round, inflated, contracted at apex, mouth toothed. Capsule 4-valved, of thick consistence, naked. Elaters geminate, naked, deciduous."—Dumortier.

(*a*). *Amphigastria present.*

1. *Cephalozia Francisci*, Hook. (Dumort.) Stems nearly erect, slightly branching. Leaves incumbent, ovate, acutely emarginate. Amphigastria minute, ovate, bifid. Colesule terminal, on short lateral branches.

Jungermannia Francisci, Hook. Brit. Jung. t. 49; Engl. Bot. t. 2369; Taylor, in Fl. Hib. 2, p. 64; Nees, Europ. Leberm. 2, p. 220; G. L. et N. Synop. Hepat. p. 133; Rabenhor. Hepat. Europ. exsic. n. 503. Cephalozia Francisci, Dumort. Rev. Jung. p. 18; Hepat. Europ. p. 88; Cogn. Hepat. Belg. p. 35.

Hab. Shady banks and rocks. Near Bantry, Miss Hutchins. Very rare in Ireland.

2. *Cephalozia divaricata*, Smith (Dumort.) Autœcious. Stems creeping. Leaves roundish and semi-bifid, segments divergent. Amphigastria subulate, bifid. Colesule terminal, cylindrical, truncate, toothed at the mouth.

Jungermannia divaricata, Sm. Engl. Bot. t. 719; Spruce, in Trans. Bot. Soc. Edinb. 3. p. 207. J. Starkii, G. L. et N. Synop. Hepat. p. 134. Cephalozia Starki, Dumort. in Cogn. Hep. Belg. p. 35. Trigonanthus divaricatus, Hartm. Skand. Fl. 10 ed., p. 143.

Hab. On heathy banks in hilly places. Sleemish Mountain, and Fair Head, Co. Antrim; Brandon, Kerry. Cromagloun, Kerry, Dr. Carrington. Near Glenarm, Dr. Dickie.

3. *Cephalozia elachista*, Jack. Parœcious. Stems very small and somewhat rigid. Leaves variable, inclined to quadrate, deeply bifid but sometimes entire, segments nearly linear, bearing occasionally a well-developed tooth or two, but more frequently without teeth. Amphigastria generally present, especially among the perichætial leaves. Involucral bracts much larger than the cauline leaves, irregularly lobed, lacerated at the margin, and imbricated on every side. Perigonial leaves strongly toothed at their margins, and terminating in longish incurved points. Gamœcium and Andrœcium on same branch, but separate (parœcious). Colesule roundish or inclined to triangular, but rather variable in form, contracted and ciliated at the mouth. Antheridia with short stalks in the axils of the perigonial leaves, singly.

Jungermannia elachista, Jack. in Gottsche et Rabenhor. Hepat. Europ. exsic. no. 574, with excellent figure and full description by Dr. Gottsche.

Hab. On moist bare banks at Brandon, Co. Kerry (1864). At Lough Bray, Co. Wicklow, Dr. Lindberg, June, 1873.

(*b*). *Amphigastria wanting.*

4. *Cephalozia byssacea* (Roth), Dumort. Stems procumbent, branching. Leaves remote, incumbent, subquadrate, bifid, segments acute. Colesule terminal, cylindrical, plicate, toothed at the mouth.

Jungermannia byssacea, Roth, Fl. Germ. 3, p. 387; Hook. Brit. Jung. t. 12; Taylor, in Fl. Hib. 2, p. 60; Fl. Dan. t. 1717, f. 1; De Notaris, Prim. Hep. Ital. p. 29. Cephalozia byssacea, Dumort. Rev. Jung. p. 18; Hepat. Europ. p. 90; Cogn. Hep. Belg. p. 33.

Hab. "On paths in woods, and on bare crags; common."—Dr. Taylor.

I have enumerated this so-named plant out of deference to some of our greatest hepaticists, although I am by no means clear about the characters which distinguish it from C. divaricata. Dumortier places the two in different sections of Cephalozia, and refers C. divaricata to the figure in English Botany quoted, and C. byssacea to the figure in Hooker's British Jungermanniæ. I had collected in various parts of Ireland what I considered to be the latter, but when my specimens were examined by Drs. Carrington and Lindberg, they referred all of them to C. divaricata, Engl. Bot. Dr. Taylor states it to be common in Ireland. The presence or absence of amphigastria do not appear to be decisive distinguishing characters, as Mr. Spruce states in his remarks on Jung. divaricata (in Hepat. Pyrenees, Trans. Bot. Soc. Edinb., 3, p. 207), that some of his specimens have stipules, and some are altogether without them.

5. *Cephalozia bicuspidata* (Linn.), Dumort. Autœcious. Stem creeping, branched. Leaves incumbent, lax, subquadrate, bifid, segments long, acute. Involucral bracts 2-3 cleft, imbricated. Colesule radical and terminal on lateral branches, plicate and toothed at the mouth.

Jungermannia bicuspidata, Linn. Sp. Pl. 158; Hook. Brit. Jung. t. 11; Engl. Bot. 2239; Nees, Europ. Leber. 2, p. 351; De Notaris, Prim. Hepat. Ital. p. 27; G. L. et N. Synop. Hepat., p. 138. Cephalozia bicuspidata, Dumort. Rev. Jung., p. 18; Hep. Eur. p. 91. Trigonanthus bicuspidatus, Hartm. Skand. Fl. 10 ed., p. 143.

Var. a. major, Nephin Mountain, Mayo.

Var. β. rigidula, Cromagloun, Kerry, Dr. Carrington.

Hab. On heaths and banks. A very common species in many parts of Ireland.

6. *Cephalozia curvifolia* (Dickson), Dumort. Autœcious. Stems procumbent. Leaves semi-verticillate, concave, deeply bifid, segments long, setaceous at the points, and much incurved. Colesule on lateral branches, oblong, subplicate, contracted, and toothed.

Jungermannia curvifolia, Dicks. Pl. Crypt. 2, p. 15, t. 3, f. 7; Hook. Brit. Jung. t. 16; Engl. Bot. t. 1304 (not good); Carring. in Trans. Bot. Soc. Edinb., vol. 7, pl. 11, fig. 4; Lindenb. Synop. Hep. p. 91; Taylor, in Fl. Hib. 2, p. 60; G. L. et N. Synop. Hepat. p. 142; Rabenhor. Hep. Europ. exsic. n. 72, 217, &c. Cephalozia curvifolia, Dumort. Hepat. Europ., p. 93.

Hab. On decaying trunks of trees; also on moss-covered banks, among mosses. Frequent about Killarney; Connor Hill, Kerry; Kylemore, Galway; Glenade, Leitrim.

Var. β. Baurери = Cephalozia Baueri, Lindberg.

Hab. Cromagloun, and elsewhere in the Killarney district.

7. *Cephalozia connivens*, Dicks. Stem procumbent, slightly branched. Leaves accumbent, suborbicular, concave, deeply bifid, segments incurved, connivent. Colesule terminal, on lateral branches, ovate, contracted and ciliated at the apex.

Jungermannia connivens, Dicks. Pl. Crypt., fasc. 4, p. 19, tab. 2, fig. 15; Hook. Brit. Jung. tab. 15; Engl. Bot., t. 2436; Tayl. in Fl. Hib., p. 2, p. 60; De Not., Prim. Hep. Ital., p. 27. Blepharostoma connivens, Dumort. Rev. Jung., p. 18; Hepat. Europ., p. 96 (1874); Cogn. Hepat. Belg., p. 36.

Hab. Wet banks among mosses, and bogs among Sphagnum. Rather common in many parts of Ireland, but more abundant in the southern and western counties.

Var. a. conferta minor. On rotten wood frequent, Carrington.

Var. β. sphagnorum, Hook. Brit. Jung., t. 15, 3. More or less frequent among Sphagnum in many of the bogs through Ireland, but never in much quantity together.

8. *Cephalozia catenulata* (Hübener), Lindb. Stem ascending, flexuose, rigid. Leaves ovate, concave, acutely bifid, adpressed. Involucral bracts bi-tri-fid. Colesule cylindrically trigonous, minutely toothed at the apex.

Jungermannia catenulata, Hübener, Hepat. Germ., p. 169; Nees, Eur. Leber. 11, p. 248; G. L. et N. Synop. Hepat., p. 138; Rabenhor. Hep. Eur. exsic., p. 435, *cum ic.* Jungermannia reclusa, Taylor, in Trans. Bot. Soc. Edinb. 11, p. 44; et Lond. Journal Bot. 5, p. 278; Spruce, Musc. et Hepat. Pyren. in Trans. Bot. Soc. Edinb. III., p. 208; Bot. Zeit. 1, p. 694. J. catenulata, Carring. in Trans. Bot. Soc. Edinb. 7, p. 449. t. 11, fig. 2. Cephalozia catenulata, Lindb. in Jour. Linn. Soc. vol. XIII. p. 191.

Hab. On shady damp banks, and in woods. Very common in the Killarney and Cromagloun woods; also about Brandon Mountain as well as elsewhere in Co. Kerry; about Kylemore, Co. Galway; Lackan bay, Co. Mayo; Gleniff, Co. Leitrim; Lough Bray, Co. Wicklow.

This pretty little plant is rather puzzling at times to distinguish from certain states of other species of the genus. It bears a greater resemblance to young forms of C. connivens than to any other. Dr. Carrington, who has paid great attention to it, and figured it (Trans. Bot. Soc. Edinb. *l. c.*), considers Taylor's J. reclusa identical with Hübener's C. catenulata, as also does Dr. Lindberg, who has had such excellent opportunities for comparing the Irish plant with foreign specimens of C. catenulata. Dumortier, however, holds that they are distinct species, and describes them as such (Hepat. Europ., p. 92 (1874)). Dr. Spruce, another excellent observer, agrees with Dumortier, and describes J. reclusa, Taylor (see his Musc. et Hepat. Pyren., in Trans. Bot. Soc. Edinb., III. p. 208, as a distinct species).

9. *Cephalozia Turneri* (Hook.), Lindb. Stems creeping, branched. Leaves incumbent, acutely bipartite, segments conduplicate, spinulose-dentate. Colesule terminal, contracted and slightly dentate at the mouth.

Jungermannia Turneri, Hook. Brit. Jung. t. 22; Engl. Bot., t. 2310; Lindenb. Synop. Hepat., p. 92; Nees, Europ. Leber., 1, p. 265;

G. L. et N. Synop. Hepat., p. 143; Taylor, in Fl. Hib., p. 2, p. 60. Anthelia Turneri, Dumort. Rev. Jung., p. 18; et Hepat. Europ., p. 99 (1874). Cephalozia Turneri, Lindberg, in Journal of Linn. Soc., vol. XIII., p. 191.

Hab. Shady damp banks. By the side of a mountain rivulet near Bantry, Co. Cork, Miss Hutchins, bearing female fruit in March, (1811) [?] On a wet sandy bank at Cromagloun, Co. Kerry, bearing autœcious colesules, 23rd July, 1873, Dr. Lindberg. I am not aware that this exceedingly rare plant has been collected elsewhere in the British Isles, or by any other person than those named.

LOPHOCOLEA, Dumortier.

Jungermannia, Mich. Nov. Pl. Gen. p. 8, tab. 51, fig. 12 (1729); L. Sp. Pl. 1 ed., 2, p. 1132 (1753); Hooker, Brit. Jung. (1816). Lophocolea, Dumort. Recueil, 1, p. 17 (1835); Nees, Nat. Eur. Leber., 2, p. 321 (1836).

Involucre oligophyllous, dentate or cleft. Colesule sessile, cylindrical, mouth 3-cleft and cristated.

1. *Lophocolea bidentata,* Linn. (Dumort.) Autœcious. Stem procumbent, branched. Leaves accumbent, broadly ovate, slightly decurrent and emarginate, acutely bidentate. Amphigastria bi-tri-fid, laciniated. Colesule oblong-triangular, mouth laciniated. Antheridia in the axillæ of the perigonial bracts, two or three together.

Jungermannia bidentata, Sm. Engl. Bot. t. 606; Hook. Brit. Jung. t. 30; Taylor, in Fl. Hib. 2, p. 64. Lophocolea bidentata, Dumort. Rev. Jung., p. 17; et Hepat. Europ., p. 83. Lophocolea Hookeriana, Nees, G. L. et N. Synop. Hepat., p. 161; Cogn. Hepat. Belg., p. 33; G. L. et N. in Synop. Hepat. Europ. The latter refer the J. bidentata, Linn., to another species, and state that the var. γ. of it is found near Dunkerron, Kerry, by Dr. Taylor. We suppose this is the form he mentions in Fl. Hib. 2, p. 64, which grows near Blackwater bridge, "with the calyces acutely triangular, the angle corresponding to the inferior side of the stem serrate."

Var. *β. cuspidata* (Gottsche). On dead trees, Killarney, Dr. Carrington.

Var. *γ. gracile,* Carrington, Irish Hepat., Trans. Bot. Soc. Edinb., vol. 7, p. 452, pl. 11, fig. 6. Woods, Killarney.

2. *Lophocolea heterophylla* (Schrad.), Dumort. Stems ascending, branched. Leaves roundish, quadrangular, obtusely emarginate. Involucral bracts lobed and dentate. Amphigastria 2-3 fid, and dentate. Colesule terminal, mouth crested.

Jungermannia heterophylla, Schrad., Journal Bot. 1, p. 66; Hook. Brit. Jung. t. 31; De Notaris, Prim. Hepat. Ital. p. 25. Lophocolea heterophylla, Dumort. Rev. Jung., p. 17, et Hepat. Europ., p. 86; Nees, Europ. Leber. 2, p. 338; G. L. et N., Synop. Hepat., p. 164.

Hab. In woods and on banks. Torc Mountain, Killarney, Dr. Carrington. Near Cong, Co. Galway. Near Fermoy, Isaac Carroll, Esq. Dr. Taylor unites this species with the former in Flora Hibernica, and states that he finds in Kerry varieties so intermediate that with the utmost care he found it impossible to refer them definitely to one more than the other. (Fl. Hib. p. 2, p. 65 (1836)).

3. *Lophocolea spicata*, Taylor. Autœcious. Stem creeping, branched. Leaves oval-horizontal, 2-, 3-, or more toothed at the apex. Amphigastria small, cleft nearly to the base. Colesule terminal, prismatical, and lacerated at the mouth, lobes toothed.

Lophocolea spicata, Taylor, in G. L. et N. Synop. Hepat., p. 167; Cooke, Brit. Hepat., p. 15, n. 75, fig. 113; Dumort. Hepat. Europ., p. 86.

Hab. On shady damp rocks among mosses. Dunkerron, Kerry, Dr. Taylor. Bantry, Miss Hutchins. Torc Cascade, Killarney, Dr. Carrington. Glensiskin, Cork, T. Chandlee, Esq. By the side of the Upper Lake, Killarney, in fruit, June, 1869; Altadore Glen, Wicklow, 1873.

PEDINOPHYLLUM, Lindberg.

Jungermannia, Nees, Nat. Europ. Leber. 1, p. 165 (1833). Plagiochila, Dum. Recueil, 1, p. 15 (1835). Pedinophyllum, Lindb. Soc. Fauna et Fl. Fenn. (Oct. 1874), and in Bot. Not. p. 156 (1874).

Pedinophyllum pyrenaicum, Spruce. Autœcious. Tufts dense, much interwoven, of a brownish yellow colour. Stems spreading, radiculose, creeping on the surface of earth or rocks where they grow, sparingly branched, branches axillary, or proceeding from the under surface of the stem. Leaves somewhat rigid, slightly shining when dry, densely placed on the stem, and distichous, broad at the base and quadrate towards the apex, which is variously notched and toothed. Amphigastria very small, and likely to be overlooked, though they are mostly present, especially near the points of barren shoots, 1–3 parted, segments subulate. Involucral bracts much larger than the cauline leaves, oblong-ovate, slightly emarginate at apex, with recurved margins. Colesule compressed, a little prominent, short, obovate-oval, mouth broad and rounded, lips semi-oval, irregularly cut, and dentate. Andrœcium terminal, interruptedly spicate, on same stem as the fertile shoots, or on distinct branches on same plant.

Perigonial bracts smaller, imbricated, bilobed. Antheridia usually solitary, in the saccate axils of the perigonial bracts.

Plagiochila pyrenaica, Spruce, Hepat. Pyren. n. 9. (1847), and in Trans. Bot. Soc. Edinb. III., p. 200 (1849); Lindb. Manipulus Muscorum secundus, in Faun. et Flor. Fenn., 13, p. 366 (1874). Plagiochila interrupta, var. β. pyrenaica, Carring. Brit. Hepat. pl. 3, figs. 2–9 (1874).

Hab. Shady rocks and banks, mostly in limestone districts. On rather dry banks through the Benbulben range, Co. Sligo, where I collected it for the first time it was found in Ireland (1871); again at Gleniff, in same district (1875). This plant may be quoted as an instance of the difficulty which the Hepaticæ present to the systematist, in not affording good generic characters, that can be stated in words which will enable the student to distinguish them clearly one from the other. As Dr. Lindberg well observes in his description of this plant in his Irish Hepaticæ, it possesses nothing in common with Plagiochila, except the compressed colesule. The affinities are altogether with the Chiloscyphiæ. In general appearance it resembles C. polyanthos; yet it approaches even more both in habit and aspect Saccogyna viticulosa.

CHILOSCYPHUS, Corda.

Jungermannia, Mich. Nov. Pl. Gen. p. 8, tab. 5, fig. 5 (1729); Linn. Sp. Pl. 1 ed., 2, p. 1131 (1753); Hook. Brit. Jung. (1816). Mylia, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 693 (1821). Marsupella, Dumort. Comm. Bot., p. 114 (1823). Chiloscyphus, Corda, in Opiz, Beitr. 1, p. 651 (1829); Dumort. Syll. Jung. Europ., p. 67 (1831).

Involucral bracts imbricated on each side and notched at the margin. Colesule rather short and bilabiate, the lips irregularly notched, fruit stalks long, pedicels inarticulate, rising from the under part of the stem.

Chiloscyphus polyanthos, Corda. Stems prostrate, growing in patches. Leaves in two rows, overlapping, inclining to quadrate, entire or slightly emarginate. Amphigastria bifid, toothed or variously cut. Colesule short, cleft into two lips, which are laciniated.

Jungermannia polyanthos, Linn. Sp. Pl. 1597; Hook. Brit. Jung. t. 62; Lindenb. Synop. Hepat., p. 30. Marsupella polyanthos, Dumort. Comm. Bot., p. 114. Chiloscyphus polyanthos, Corda, in Sturm, Deutschl. Crypt. 19, p. 33, t. 9; Dumort. Syll. Jung., p. 67, t. 1, f. 9; et Jung. Europ., p. 101; G. L. et N. Synop. Hepat., p. 188.

Var. β. rivularis, Nees. Stems dichotomous, succulent. Amphigastria sometimes obsolete.

Var. γ. pallescens, Lindenberg.

Hab. On wet ground, where water often remains during a considerable period of the year.

The var. β. rivularis is also common in similar situations. Lindberg observes that the inflorescence of this variety is autœcious. Var. γ. pallescens occurs about Killarney, according to Dr. Carrington, who considers there is no valid distinction between it and the typical form. Dumortier, however, gives it a place as a distinct species (see his Hepat. Europ. p. 101 (1874)). T. Chandlee finds it also near Fermoy, Cork.

HARPANTHUS, Nees.

Jungermannia, W. M. Bot. Taschenb. p. 408 (1833); Nees, in Flora, 16, p. 2, p. 408 (1833). Lophozia, Dum. Recueil, 1, p. 17, n. 19 (1835). Harpanthus, Nees, Nat. Europ. Leber. 2, p. 351 (1836); Spruce, in Trans. Bot. Soc. Edinb. 3, p. 209 (1849); Mitten, in Journ. L. Soc. 8, p. 52 (1864). Pleuranthe, Taylor, in Hook., Lond. Journ. Bot. 5, p. 282 (1846).

Colesule fusiform, exserted, 3-4 cleft at the mouth, divisions unequal, connate at the base with the calyptra. Involucral bracts of one or two pairs, with amphigastria interposed. Calyptra adhering to the walls of the colesule for more than half its length.

Harpanthus scutatus, Spruce. Diœcious. Stems mostly crowded together in incoherent tufts, or smaller and cæspitose, quarter to half an inch long or more, ascending. Leaves succubous, crowded, acutely emarginate at the apex. Amphigastria ovate-acuminate, slightly toothed at the base. Colesule obovate, contracted at the mouth, and subplicate. Calyptra adherent with the base of the colesule.

Jungermannia scutata, Weber et Mohr, Deutschl. Crypt., p. 408; Lindenb. Synop. Hep., p. 38; Dumort. Syll. Jung., p. 56, excl. var. γ.; Taylor, in Fl. Hib. 2, p. 64; G. L. et N. Synop. Hepat. p. 101; Rabenh. Hepat. Europ. exsic. 218–466; Cooke, Brit. Hepat., p. 10, tab. 72. Jungermannia stipulacea, Hook., Brit. Jung. t. 41; Engl. Bot. tab. 2538; Carring., Brit. Hepat. p. 49, pl. 7, fig. 52; Dumort. Hepat. Europ. p. 67.

Hab. Moist banks and on rocks among the larger mosses, &c. This species is rather local in Ireland, and confined chiefly to the southern counties. Near Bantry, Cork, Miss Hutchins (1812). Lough Bray, Wicklow, Dr. Taylor. Killarney, W. Wilson, Esq. At Cromagloun and Glena, Kerry; I have collected it during my occasional visits to these places at various times; also at Lough Bray, Wicklow.

Sub-tribe 4. SACCOGYNEÆ, Dumortier.

Involucral bracts wanting. Colesule pendulous, fixed by the margin to the under side of the stem.

KANTIA, Bennett, Gray.

Jungermannia, Mich. Nov. Pl. Gen., p. 8, n. 2, tab. 5, fig. 14 (1729); Dicks. Fasc. Pl. Crypt. Brit. 3, p. 10, tab. 8, fig. 5 (1793); Hook. Brit. Jung. (1816). Kantia, B. Gr. in Gray's Nat. Arr. Brit. Pl. 1, p. 706 (1821). Cincinnulus, Dumort. Comm. Bot. p. 113 (1823). Calypogeia, Corda, in Opiz, Beitr. 1, p. 653 (1829).

Colesule dorsal, oblong-acuminate, lobed at the mouth, and hairy, subterranean.

1. *Kantia trichomanis* (Dicks.), B. Gr. Stem procumbent, branched. Leaves succubous, ovate, entire or emarginate. Amphigastria orbicular, crenulato-emarginate.

Jungermannia trichomanis, Dicks. Pl. Crypt. fasc. 3, t. 8, f. 5; Hook. Brit. Jung. tab. 79; Ekart, Synop. Jung. p. 40, tab. 4, fig. 35; Fl. Dan. tab. 1896; Engl. Bot. tab. 1875; Taylor, in Fl. Hib. 2, p. 64. Calypogeia fissa, Raddi, Mem. Mod. 18, p. 44; G. L. et N. Synop. Hep. p. 198. Cincinnulus trichomanis, Dumort. Syll. Jung. p. 72; Rev. Jung. p. 21, et Hepat. Europ. p. 15.

Hab. On wet shady banks and woods. Frequent in many parts of Ireland; very abundant about Killarney.

2. *Kantia arguta* (N. M.), Lindb. Diœcious. Stem elongated near the apex, with smaller and more remotely placed leaves, often tipped with gonidiferous gemmæ. Leaves roundish, oblique, apex bidentate, fragile, divergent. Amphigastria deeply bifid, segments subulate, divergent.

Calypogeia arguta, N. M., in Nees, Europ. Leber. 3, p. 24, n. 2; G. L. et N. Synop. Hepat., p. 199, n. 2; Dill. Hist. Musc. tab. 70, fig. 12; Engl. Bot. tab. 1875. Cincinnulus argutus, Dumort. Hepat. Europ. p. 117 (1874). Kantia arguta, Lindberg, in Manipulus Muscorum secundus, p. 363, Helsingfors (1874).

Hab. On wet banks. Very rare in Ireland. The few Irish specimens known were collected at Luggielaw, Wicklow, creeping over the stems of Nardia compressa. Dr. Lindberg detected them among my specimens when examining them.

SACCOGYNA, Dumortier.

Jungermannia, Mich. Nov. Pl. Gen., p. 8, tab. 5, fig. 4 (1729); Sm. Engl. Bot. tab. 2513 (1813); Hook. Brit. Jung. (1816). Lippia, B. Gr. in Gray's Nat. Arr. Br. Pl. 1, p. 706 (1821). Saccogyna, Dum. Comm. Bot., p. 113 (1823). Sykorea, Corda, in Opiz, Beitr. 1, p. 653 (1829). Calypogeia, Raddi, MSS., Corda, in Sturm, Deutschl. Fl. (1830). Geocalyx, Nees, Nat. Europ. Leber. 1, p. 97 (1833).

Involucral bracts wanting. Colesule oblong, fleshy, fimbriated at the mouth with scales, adhering to the base of the stem by its margin, and pendulous.

Saccogyna viticulosa (Mich.), Dumort. Stem procumbent, branched. Leaves succubous, flat, ovate, entire. Amphigastria ovate-lanceolate, dentate, laciniate. Colesule subterranean.

Jungermannia viticulosa, Linn. Sp. Pl. 1597; Hook. Brit. Jung. t. 60; Taylor, in Fl. Hib., p. 63; Lindenb. Synop. Hepat., p. 28. Saccogyna viticulosa, Dumort. Syll. Jung., p. 74; Rev. Jung., p. 22; et Hepat. Europ., p. 117; G. L. et N. Synop. Hepat., p. 194.

Hab. On damp ground, among mosses, &c. This fine species is of frequent occurrence in many parts of Ireland, but more especially in the south and west; very fine at Lough Bray, Wicklow, and in the woods about Killarney. It also extends to the counties of Antrim and Donegal in the north, and Mayo in the west.

Sub-section ††. ACROGAMÆ.

"Stem commonly branched by innovations proceeding from beneath the perichætium, rarely pinnate or dichotomous. Leaves succubous, sometimes conduplicate, entire, and broken up in capillary segments. Amphigastria most frequently absent, commonly small and ovate, subulate, rarely larger, and, like the leaves, undivided and broken up into capillary segments. Gamœcium diœcious or parœcious. Perichætium apical on the stem itself and its innovations.

Colesule rounded, commonly five-, or sometimes more densely, plicate, not unfrequently compressed, very rarely none. Antheridia placed in the highest axils of the stem and innovations. Paraphyses present in some, frequently leaf-shaped."—Lindberg.

Sub-tribe 5. BLEPHAROZIEÆ.

TRICHOCOLEA, Dumortier.

Jungermannia, Huds. Fl. Angl. 1 ed. p. 435 (1762); Hooker, Brit. Junger. (1816). Tricholea, Dum. Comm. Bot., p. 113 (1823), et Hep. Europ., p. 111 (1831). Tricholea, Dum. Syll. Jung. Europ., pp. 24 et 28 (1831). Trichocolea, Nees, Nat. Europ. Leber. 3, p. 103 (1838).

Involucral bracts wanting. Colesule campanulate, hairy, mouth truncate, without teeth. Capsule 4-valved. Elaters smooth.

Trichocolea tomentella (Ehrhart), Dumort. Stems dichotomous, bi-tri-pinnate. Leaves unequally 2-lobed, each lobe divided and sub-divided into long ciliary fringes. Amphigastria cleft into two portions, and fringed with cilia. Colesule apical, from the forks of the stem.

Jungermannia tomentella, Ehrh. Beitr. 2, p. 150; Dicks. Pl. Crypt. fasc. 2, p. 14; Engl. Bot. t. 2242; Hook. Brit. Jung. t. 36; Lindenb. Synop. Hepat., p. 19; Cooke's Brit. Hepat., p. 17, fig. 129; Tayl. in Fl. Hib., pt. 2, p. 66. Tricholea tomentella, Dumort. Hepat. Europ. p. 111 (1874); G. L. et N. Synop. Hepat. p. 257.

Hab. Mossy banks in woods and rocky places. Widely distributed through Ireland, from north to south, and east to west. Very abundant and fine in the Killarney woods.

BLEPHAROZIA, Dumortier.

Jungermannia, Linn. Sp. Pl., p. 1601; Hook. Brit. Jung. (1816). Section Blepharozia, Dum. Syll. Jung. p. 46 (1831). Ptilidium, Nees, Europ. Leber. 1, p. 95 (1833); Petit Thouars, Veg. Afr. Austr. t. 1, p. 11 (1806). Blepharozia, Dumort. Rev. Jung., p. 16 (1835).

Involucre oligophyllous, 2–3 lobed, segments with long cilia. Colesule pear-shaped. Mouth small, and plicately contracted.

Blepharozia ciliaris (Linn.), Dumort. Stem prostrate, pinnate. Leaves unequally 2-lobed, overlapping, lobes ciliated, deeply cleft into two pointed segments. Fruit lateral. Colesule obovate, contracted and toothed at the mouth. Amphigastria broad, quadrate, unequally lobed, and ciliated.

Jungermannia ciliaris, Linn. Sp. Pl. p. 1601; Engl. Bot. t. 2241; Hook. Brit. Jung. t. 65; Lindenb. Synop. Hepat. p. 19. Blepharozia ciliaris, Dumort. Rev. Jung., p. 16; et Hepat. Europ. p. 53; S. O. Lindberg et Lackström, Hepat. Scand. fasc. 1, n. 10. Ptilidium ciliare, Nees, Europ. Leber. 3, p. 17; G. L. et N. Synop. Hepat. p. 230; Rabenh. Hepat. n. 9–197.

Hab. Subalpine rocks. Brandon, Kerry, Dr. Taylor. Mangerton and Ross Bay, Dr. Carrington. Torc Mountain, Killarney, 1861. Rare in Ireland, and seemingly confined to the south.

MASTIGOPHORA, Nees.

Jungermannia, Brid. MSS., Web. (F.), Hist. Musc. Hep. Prodr. p. 56 (1815); Hook. Brit. Jung. p. 18 (1816). Mastigophora, Nees, Nat. Eur. Leber. 1, p. 95 (1833); Lindley, Introd. Nat. Syst. Bot., 2 ed., p. 414; Mitt. in Hook. Handb. N. Zealand Fl., 2, pp. 752–754 (1867). Blepharozia, Dum. Recueil, 1, p. 16 (1835). Sendtnera, Endl. Gen. Pl. 1, suppl. p. 1342 (1840). Herberta, Carruth. in Seem. Journ. Bot. 3, p. 300 (1865).

Mastigophora Woodsii (Hook.), Nees. Stem procumbent, bi-tri-pinnate, long, varying from three to six inches in length. Leaves much overlapping, roundish, convex, unequally 2-lobed, the upper lobe cleft, segments ciliate-dentate. Amphigastria large, broader than the stem, cleft into two spinulose-dentate segments, with a spur at the base on each side.

Jungermannia Woodsii, Hook. Brit. Jung. t. 66; Engl. Bot. suppl. t. 2668; Lindenb. Synop. Hepat. p. 20. Blepharozia Woodsii, Dumort. Recueil, 1, p. 16; et Hepat. Europ. p. 54. Mastigophora Woodsii, Nees, Eur. Leber. 3, p. 95; S. O. Lindenberg et Lackström, Hepat. Scand. fasc. 1, n. 3. Sendtnera Woodsii, G. L. et N. Synop. Hepat. p. 241; Rabenhor. Hepat. Eur. exsic. n. 367–490.

Hab. On subalpine banks. Mangerton, Kerry, Joseph Woods, Esq. Brandon, Dr. Taylor. Carrantual, Connor Hill, and Brandon. This fine species grows in large patches lying flat on the ground, and appears at first sight to resemble patches of Thuyidium tamariscinum, Schimp. In Ireland it has been seen growing only in the County of Kerry, and even there it is very local.

HERBERTA, Bennett, Gray.

Jungermannia, Sw. Prodr. Fl. Ind.-Occ., p. 144 (1788); Dicks. Fasc. Pl. Crypt. Brit. 3; Hook. Br. Jung. (1816). Herberta, B. Gr. in Gray's Nat. Arr. Brit. Pl. 1, p. 705 (1821); Carruth. in Seem. Journ. Bot. 3, p. 300 (1865). Schisma, Dumort. Comm. Bot. p. 114 (1823). Sendtnera, sect. 1, Schisma, G. L. et N. Synop. Hep. p. 239 (1845).

Involucre polyphyllous, bracts connate at their base with the perianth, variously cleft and cut. Colesule tubular, deeply cleft at the mouth, chartaceous at the base.

Herberta adunca (Dicks.), B. Gr. Stems erect, growing in large patches of a brown colour, from two to six inches long. Leaves deeply bipartite, falcato-secund. Amphigastria large, bipartite. Fruit terminal.

Jungermannia adunca, Dicks. Fasc. Pl. Crypt. Brit. 3, p. 12, tab. 8, f. 8. J. juniperinum, var. β., Hook. Brit. Jung., tab. 4. Gymnomitrium juniperinum, Corda, in Opiz, Beitr. p. 651. Schisma, Dumort. Syll. Jung. p. 76, t. 2, fig. 16 (1831); et Hepat. Europ. p. 123 (1874). Sendtnera juniperina, var. β., Nees, in G. L. et N. Synop. Hepat. p. 239.

Hab. On the sides of mountains, and on bogs. Abundant in the south and west of Ireland, but not common in the northern or eastern counties. Gleniff and Glenad, Co. Leitrim. Sir W. Hooker remarks in his British Jungermanniæ that J. juniperina has no affinity to any other British species of Jungermannia, which remark still holds true. Dumortier, in his late work on the European Hepaticæ, has placed it in his tribe Acolea, along with Gymnomitrium, which is surely unnatural, when the whole appearance of these plants is taken into consideration.

ANTHELIA, Dumortier.

Jungermannia, Linn. Fl. Lapp. 1 ed. p. 342 (1737); Hook. Br. Jung. (1816). Anthelia, Dum. Recueil, 1, p. 18 (1835). Chandonanthus, Lindb. in Act. Soc. Sc. Fenn. 10, p. 19 (1871).

Involucre polyphyllous, imbricated, segments sub-palmate. Colesule sessile, cylindrical, plicate at the mouth, and denticulate.

Anthelia julacea (Linn.), Dumort. Stem erect, branching. Leaves deeply bifid, segments acute, imbricated on every side of the stem. Colesule cylindrical, subplicate, and toothed at the mouth.

Jungermannia julacea, Linn. Sp. Pl. p. 1601; Hook. Brit. Jung. t. 2; Sm. Engl. Bot. t. 1024; Dumort. Syll. Jung. p. 63; Taylor, in Fl. Hib. 2, p. 65; Hüben. Hepat. Germ. p. 56; G. L. et N. Synop. Hepat. p. 140; Rabenhor. Hepat. Europ. exsic. n. 126–152. Anthelia julacea, Dumort. Hepat. Europ. p. 88, tab. 3, fig. 23.

Hab. Rocks; usually on the higher mountains. Maam Torc Mountain, Connemara; Macgillicuddy's Reeks, Killarney; Kylemore, Co. Galway. Forma minor, on Brandon Mountain, and Connor Hill, Kerry.

BLEPHAROSTOMA, Dumortier.

Jungermannia, Linn. Fl. Suec., 1 ed. p. 336, n. 921 (1745); Hook Brit. Jung. (1816). Blepharostoma, Dum. Recueil, 1, p. 18, n. 23 (1835). Ptilidium, Mitt. in Journ. Linn. Soc. vol. 5, p. 102 (1861).

Involucre polyphyllous, imbricated, bracteolæ articulate-ciliate. Leaves transversal. Colesule sessile, terminal, erect, round-ovate, mouth with long acute cilia.

1. *Blepharostoma tricophylla* (Linn.), Dumort. Stem creeping, branched. Leaves imbricated on every side, deeply 3–4 parted, segments setaceous, jointed, ascending. Colesule terminal, ovate, contracted and ciliated at the mouth.

Jungermannia tricophylla, Linn. Sp. Pl. p. 1601; Schmid, Icones, p. 164, t. 42; Hook. Brit. Jung. t. 7; Corda, in Sturm, Deutsch. Crypt. fasc. 26, p. 173, t. 40; G. L. et N. Synop. Hepat. p. 145; Rabenhor. Hepat. Eur. exsic. n. 15-267. Blepharostoma tricophylla, Dumort. Rev. Jung. p. 18; Cogn. Hepat. Belg. p. 36.

Hab. On turfy heaths, and in bogs among Sphagnum. Belfast, Mr. Templeton. Bantry, Miss Hutchins. Cromagloun, Dr. Carrington. Kylemore, and other places in Connemara; Nephin Mountain, Co. Mayo. This pretty plant, which is so unlike any other British species save the following, is probably more generally distributed through Ireland than it is known to be at present. It frequently grows among Sphagnum and other mosses, where it is not readily noticed.

2. *Blepharostoma setacea* (Web.), Mitt. Stems creeping. Leaves imbricated round the stem, deeply bipartite, the segments setaceous, jointed, incurved. Colesule on short lateral branches, cylindrical, mouth open and much ciliated.

Jungermannia setacea, Weber, Spicil. Fl. Gott. p. 143; Hook. Brit. Junger. t. 8; Smith, Engl. Bot. t. 2482; Dumort. Syll. Jung. p. 63; G. L. et N. Synop. Hepat. p. 144. Blepharostoma setacea, Dumort. Rev. Jung. et Hepat. Europ. p. 93. Lepidozia setacea, Lindb. Hepaticæ in Hibernia lectæ, p. 498 (1874).

Hab. Bogs, and moist shady banks in woods, &c. Very abundant in the Killarney woods, and many other parts in Co. Kerry. Less frequent through the northern and eastern counties. On moist banks, parish of Rasharkin, Co. Derry.

Sub-tribe 6. JUNGERMANNIEÆ.

Colesule and calyptra free. Fructification mostly terminal.

SCAPANIA, Dumortier.

Jungermannia, Mich. Nov. Pl. Gen. p. 6, tab. 5, fig. 16 (1729); Linn. Sp. Pl. 1 ed., p. 1132 (1753). Martinellia, sect. *a*, in Gray's Nat. Arr. Brit. Pl. 1, p. 691 (1821). Radula, Dumort. Comm. Bot. p. 112 (1823); Carruth. in Seemann's Journ. Bot. 3, p. 301; sect. 2, Lindenb. in G. L. et N. Synop. Hepat. p. 63. Plagiochila, sect. 2, Scapaniæ, Nees, in Lindb. Introduct. Bot. 2 ed. (1835).

Fructification terminal, involucral bracts two, larger than the cauline leaves. Colesule compressed, truncate at the apex, dentate or entire, decurved at first. Capsule quadrivalvous, of thickest texture. Leaves succubous, bilobed. Amphigastria wanting.

(*a*). *Lobes of the leaves subequal.*

1. *Scapania compacta*, Dumort. Stems procumbent, short, and sparingly branched. Leaves conduplicate, bilobed, lobes rounded, entire. Involucral bracts denticulate. Colesule crenulate at the mouth.

Jungermannia compacta, Roth, Germ. 3, p. 375; Lindenb. Synop. Hep. p. 58. Jungermannia resupinata, Hook. Br. Jung. t. 23 (excl. syn.); Sm. Engl. Bot. tab. 2498.

Hab. Banks among heath, &c. Common, Dr. Taylor. We have not found it to be a common species by any means, but a rare one in Ireland. The only specimens we have collected of the true plant are from the neighbourhood of Brandon, Co. Kerry. Sterile in both places where it was observed growing.

2. *Scapania subalpina*, Dumortier. *Var. β. undulifolia.* Stems sub-erect, dichotomously branched. Leaves bifarious, semi-amplexicaul, and slightly decurrent, conduplicately bilobed, lobes nearly equal.

Jungermannia subalpina, Nees, apud Lindenb. Hep. p. 55; Ekart, Synop. Jung. p. 27, t. 11, fig. 91. Scapania subalpina, G. L. et N. Synop. Hepat. p. 64, var. β. p. 65; Dumort. Rev. Jung. p. 14; Hepat. Europ. p. 36.

Hab. Rivulets where the water is constantly trickling over. Lugnaquilla Mountain, Co. Wicklow, 1864; Nephinbeg, Co. Mayo, 1862. The Irish specimens, var. β., have the stems more slender, radiculose underneath. Leaves broader, lobes more spreading.

3. *Scapania nimbrosa*, Taylor. Stems ascending or erect, slightly branched. Leaves bilobed, imbricate, dentate-ciliate, nearly equal in size, lower lobe oblong-ovate, patent.

Scapania nimbrosa, Taylor, in Lehm. Pugill. Plant. 8 (1844), p. 6; G. L. et N. Synop. Hepat. Europ. p. 662; Dumort. Hepat. Europ. p. 36; Cooke, Brit. Hepat. p. 6, fig. 46.

Hab. Among the larger mosses, &c. On Brandon Mountain, Co. Kerry, Dr. Taylor. I know nothing of this plant farther than the quotations transcribed testify.

(*b*). *Leaves broader than long; lobes rounded or blunt.*

4. *Scapania undulata* (Linn., Dill.), Dumort. Stems ascending, slightly branched. Leaves unequally 2-lobed, entire or denticulate, loose, patent, rounded, trapezoidal, of flaccid texture. Fruit terminal. Colesule oblong-incurved, mouth truncate, nearly entire.

Jungermannia undulata, Linn. Sp. Pl. 1598; Hook. Brit. Jung. tab. 22; Sm. Engl. Bot. t. 2251; Nees, Europ. Leber. 1, p. 184; Ekart, Syn. Jung. p. 26, t. 2, fig. 14. Radula undulata, Dumort. Comm. Bot. p. 112. Scapania undulata, Dumort. Jung. p. 14 (1835); Hepat. Europ. p. 37 (1874); G. L. et N. Synop. Hepat. p. 65 (1844); Gottsche et Rabenhor. Hep. Eur. exsic. n. 194, 34, 90, 260, 291; Cogn. Hepat. Belg. p. 20.

Hab. Streamlets among the hills. This, one of our largest and finest British species, is of frequent occurrence in Ireland. The stems sometimes attain to the length of 3–4 inches, and are generally of a purplish colour, or of a bright shining green.

Var. β. purpurascens, Hüben. Germ. Hepat., is common in Co. Kerry.

Var. ε. speciosa, Rabenhor. Hep. Eur. exsic. n. 442, was collected near Lugnaquilla, Co. Wicklow. A very large and unusual form occurs in the deep lake at the top of the glen leading to Brandon Mountain from the Clogreen side. There the plant floats in deep water, and has black wiry stems six inches or more in length, with intensely green leaves, much cut and lacerated by aquatic insects.

5. *Scapania uliginosa* (Nees), Dumort. Stems ascending. Leaves conduplicate, unequally bilobed, the lobes roundish and entire in the margins, larger lobe anteriorly reclined, smaller about one-fourth the size of the larger lobe. Colesule entire at the mouth.

Scapania uliginosa, Dumort. Rev. Jung. p. 14; Hepat. Europ. p. 39; G. L. et N. Synop. Hepat. p. 67; Cooke's Brit. Jung. p. 6, figs. 44, 45.

Hab. Marshy places among heath on the mountains. Near the Hunting Tower, Cromaglaun (1875); Connor Hill, Co. Kerry (1873).

6. *Scapania irrigua*, Nees (Dumort.) Stems creeping. Leaves bilobed, conduplicate, lobes very unequal, anterior lobe much the smallest, and curved at the apex. Involucral bracts bifid, lobes nearly equal. Colesule ovate, compressed, toothed at the mouth.

Jungermannia irrigua, Nees, Europ. Leber. 1, p. 193. Scapania irrigua, Dumort. Rev. Jung. p. 15; Hepat. Europ. p. 37; G. L. et N. Synop. Hep. p. 67; Carring. Irish Hepat., Trans. Bot. Edinb. 7, p. 447; Cooke's Brit. Hepat. p. 6, fig. 47.

Hab. Marshy wet places among the hills. Knockavohila, Co. Kerry, Dr. Taylor. Cromaglaun; Marsh on Benbulben, Sligo; Lough Bray, Wicklow. This plant bears more of general resemblance to S. nemorosa than it does to S. undulata. Only small portions of it were collected in the localities mentioned.

(*c*). *Leaves longer than broad; lobes more or less acute.*

7. *Scapania æquiloba*, Dumort. Diœcious. Stems loosely tufted, ascending. Leaves bilobed, the lobes large, nearly equal, dentate, lower lobe roundish-ovate, apiculate. Colesule oblong, compressed, mouth oblique, truncate, denticulate, scarcely longer than the involucral bracts. Capsule ovate.

Jungermannia æquiloba, Schwægr. Prodr. Hepat. p. 214; Ekart, Synop. Jung. t. 11, fig. 90. Radula æquiloba, Dumort. Syll. Jung. p. 39. Scapania æquiloba, Dumort. Rev. Jung. p. 14, et Hep. Europ. p. 36; G. L. et N. Synop. Hepat. p. 64; Carring. Brit. Jung. p. 81, n. 3, pl. 8, fig. 26, *ex parte* (1875).

Hab. Rocky places in subalpine countries. Near the head of Gleniff, Co. Leitrim (1875), growing near Saxifraga nivalis. This is the only Irish locality I feel safe in quoting for this species. All the other Irish specimens I have seen, which have been named S. æquiloba by some of our best authorities, are states of Scapania resupinata, Dumort. = Martinellia gracilis, Lindberg. The verrucose epidermic layer of the areolation of the leaves, first observed and pointed out by Dr. Lindberg, seems the only real character by which this plant can be distinguished from its near allies.

8. *Scapania resupinata*, Dumort. Diœcious. Shoots in crowded tufts for the most part, but sometimes more lax and scattered, mostly

fawn-coloured, or of a dirty green. Leaves closely imbricated on the stem, bilobed, lower lobe roundish, apiculate, reflexed, the smaller lobe half the size of the other, roundish, concave, margins of both lobes more or less ciliately dentate. Colesule truncate, dentate at the mouth. Capsule oval.

Jungermannia resupinata, Linn. Sp. Pl. 1599; Engl. Bot. t. 2437 (non Hook.); Ekart, Synop. Jung. p. 26, t. XI. fig. 88 (excl. fig. 3). Scapania resupinata, Dumort. Rev. Jung. p. 14, et Hepat. Europ. p. 34; Carring. Brit. Junger. part 4, p. 77, pl. 8, fig. 26 (*ex parte*) (1845). Scapania æquiloba, var. foliis lævibus, Gottsche, MSS. Jens. in Bot. Tidsskr. 2, p. 288, n. 47 (1868). Martinellia gracilis, Lindb. in Not. Soc. F. Fl. Fenn. 13, p. 365 (1874); Acta Societatis Scientiarum Fennicæ, x., p. 520 (1875). Jungermannia recurvifolia, γ. recurvifolia, Hook. Jung. t. 21, f. 8.

Hab. Open heathy places chiefly, but also in woods and among rocks in the more subalpine parts of the country. Very common and widely distributed over Ireland, where it has been doing duty for Scapania nemorosa, which latter, so far as I have seen or am aware, is rare in Ireland. Dr. Carrington (in British Jungermanniæ, part 4, p. 79) states he had done his best to investigate the synonymy of this species, having devoted several days to it, with anything but satisfactory results. To me the results appear to be more important than they do to the author, as they have enabled me to understand clearly a very common plant in Ireland, which I never did before, nor do I think any former Irish cryptogamic botanist understood it. Dr. Taylor's Jungermannia resupinata (in Fl. Hib. p. 2, p. 62) is Hooker's plant (figured at tab. 23, Brit. Jung. under that name) = J. compacta, Roth; Scapania compacta, Dumort. Dr. Taylor certainly considered the present species as a state of nemorosa, and named it so repeatedly. Dumortier has defined Smith's plant during a considerable number of years past, both in his Recueil Jungermanniæ (1835), and Hepaticæ Europæ (1874). Although it varies much in size according to locality, it is constant to its leading characters, and mostly to the peculiar fawn colour. On the western coast of Ireland, I have seen it in dense compact patches, nearly half a yard wide, where the moist winds from the Atlantic were favourable for its growth. On Muckish Mountain, Co. Donegal, I have seen it tall and straggling among the heath in loose stems, quite unlike the fawn-coloured patches on the west coast, yet easily recognizable as the same plant.

9. *Scapania nemorosa,* Dumort. Diœcious, rarely autœcious. Stems laxly cæspitose. Shoots more or less erect. Leaves of a bright green colour when fresh, pale green when dried, unequally bilobed, inferior lobe obovate, recurved, smaller lobe about half the size, both with ciliate-dentate margins. Colesule partly immersed, mouth truncate-ciliate.

Jungermannia nemorosa, Linn. Sp., ed. 3, p. 1598; Engl. Bot. t. 607; Hook. Brit. Jung. t. 21 (excl. var. omn.); Taylor, in Fl. Hib. p. 2, p. 61; Mart. Fl. Crypt. Erlang. p. 152, t. 4, fig. 28; Lindenb. Synop. Hepat. p. 51; De Not. Prim. Hep. Ital. p. 10. Radula nemorosa, Dumort. Comm. Bot. p. 112. Scapania nemorosa, Dumort. Rev. Jung. p. 14 (1835), et Hepat. Europ. p. 38 (1874); G. L. et N. Synop. Hepat. p. 68 (1844); Carring. Brit. Junger. part 4, p. 74, pl. 5, fig. 15 (1875).

Hab. Damp shady banks and woods. Woods at Kylemore, Co. Galway, and at Killarney. Among rocks more or less humid at Cromaglaun and Torc Waterfall, Kerry, Dr. Lindberg.

10. *Scapania planifolia*, Hook. Stem erect. Leaves quadrifariously imbricated on stem, bipartite, lobes unequal, inferior largest, ovate, superior cordate, margins dentate-ciliate.

Jungermannia planifolia, Hook. Brit. Jung. t. 67; Engl. Bot. suppl. t. 2695; Hook. and Tayl. Musc. Brit. ed. 2, p. 232; Ekart. Synop. Jung. p. 23, t. 10, fig. 83. Scapania planifolia, Dumort. Rev. Jung. p. 14; Hepat. Europ. p. 40; G. L. et N. Synop. Hepat., p. 68.

Hab. On high mountains, growing among the large mosses. Brandon Mountain, Co. Kerry, Dr. Taylor and W. Wilson, Esq. This extremely rare plant has not been found in any other locality in Ireland than that indicated. During my several visits to Brandon I have sought for it there, but have never been successful in finding it.

11. *Scapania umbrosa* (Schrader), Dumort. Stem short, decumbent, slightly branched. Leaves conduplicate, unequally bilobed, inferior lobe tapering to an acute point, which is recurved, smaller lobe ovate-ligulate, margins sharply serrate. Colesule incurved, compressed, truncate at mouth. Apex of shoots frequently covered with a dark grumose mass of gemmæ.

Jungermannia umbrosa, Schrader, Samml., 2, p. 5; Hooker, Brit. Jung. t. 24, suppl. 3; Engl. Bot. t. 2527; Taylor, in Fl. Hib. p. 2, p. 62. Scapania umbrosa, Dumort. Rev. Jung. p. 14, et Hepat. Europ. p. 38; G. L. et N. Synop. Hep. p. 69.

Hab. Moist rocks and banks. Near Dublin, Dr. Taylor. Lough Bray, Wicklow; Kylemore, Co. Galway. Frequent in the Killarney woods, especially where there is shade and moisture; Brandon, Kerry.

12. *Scapania curta*, Dumort. Stems very short, ascending. Leaves distichous, unequally bilobed, inferior lobe largest, roundish, apiculate, lobule smaller, acute, erect, and spreading, margins of both slightly and unequally denticulate. Colesule terminal, half immersed, compressed, mouth truncate, dentate.

Jungermannia nemorosa, var. δ. denudata, Hook. Brit. Jung. t. 21, ff. 17–19. Jungermannia curta, Mart. Fl. Crypt. Erlang. p. 148, p. 148, t. 4, fig. 24; Lindenb. Synop. Hep. p. 56, n. 52; Nees, Leber. Eur. 1, p. 214. Radula curta, Dumort. Syll. Jung. p. 40. Scapania curta, Dumort. Rev. Jung. p. 14 (1835), et Hepat. Europ. p. 39 (1874); G. L. et N. Synop. Hep. p. 69; Rabenhor. Hepat. Eur. exsic. n. 395, 196, 382; Cogn. Hepat. Belg. p. 22; Carring. Brit. Jung. part 4, p. 86, pl. 7, fig. 23.

Hab. Moist shady banks, in woods, &c. Sillaghbraes and Sleemish Mountain, Co. Antrim; Gleniff, Co. Leitrim; Benbulben range, Sligo. Abundant at Cromaglaun and other places about the Killarney woods; wet banks near the sea, on an island off Ballinakill harbour, near Letterfrack, Co. Galway. This species and S. umbrosa are often found together, when it is sometimes difficult to define them.

DIPLOPHYLLUM, Dumortier.

Jungermannia, Mich. Nov. Pl. Gen. p. 8, tab. 5, fig. 9 (1729); Linn. Fl. Suec., 1 ed., p. 335 (1745); Hook. Brit. Jung. (1816). Diplophyllum, Dum. Recueil, 1, p. 15 (1835). Scapania, Mitt. in Hook. Fl. Tasm. 2, p. 233 (1858).

Involucre oligophyllous. Leaves conduplicate, bilobed. Colesule round, denticulate, peduncle inarticulate. Capsule quadrivalved, naked.

1. *Diplophyllum albicans* (Linn.), Dumort. Stems ascending. Leaves unequally 2-lobed, conduplicate, dorsal lobe ovate, ventral lobe larger, oblong-ovate, both with a broad pellucid line in the middle. Colesule terminal, obovate, contracted at the mouth, and toothed.

Jungermannia albicans, Linn. Sp. Pl. p. 1599; Hook. Brit. Jung. t. 23; Engl. Bot. t. 2240; G. L. et N. Synop. Hepat. p. 75; Rabenhor. Hepat. Europ. exsic. n. 13, &c. Diplophyllum albicans, Dumort. Rev. Jung. p. 16; Hepat. Europ. p. 48; Cogn. Hepat. Belg. p. 25.

Hab. Moist banks, and in shady woods, &c. This is probably the most widely diffused and commonest species in Ireland. It varies much in size and appearance, according to the localities where it grows.

2. *Diplophyllum obtusifolium* (Hook.), Dumort. Diœcious. Stems simple, ascending. Leaves bifarious, conduplicate, unequally lobed, lobes falcate, rounded at the apex. Colesule terminal, plicate towards the apex, which is contracted and toothed. Antheridia in the axils of the perigonial leaves, on the upper portion of the male plant.

Jungermannia obtusifolia, Hook. Brit. Jung. t. 26; Smith, Engl. Bot. t. 2311; Lindenb. Synop. Hepat. p. 60; Dumort. Syll. Jung. p. 46; Ekart, Synop. Jung. p. 30, t. 7, fig. 37, Nees, Europ. Leber. 1, p. 237; G. L. et N. Synop. Hepat. p. 76; Gottsche et Rabenhor. Hepat. Eur. exsic. n. 12–302. Diplophyllum obtusifolium, Dum. Rev. Jung. p. 16, et Hepat. Europ. p. 50; Cogn. Hepat. Belg. p. 24.

Hab. On moist clay banks. Near Bantry, Co. Cork, Miss Hutchins (1812)? Near Dunkerron, Co. Kerry, Dr. Taylor. Dunscome's Wood, near Cork, W. Wilson, Esq. (1829). Very rare in Ireland. The localities quoted are the only places where it has hitherto been observed.

PLAGIOCHILA, Dumortier.

Jungermannia, h. Nov. Pl. Gen. p. 7, tab. 5, fig. 1 (1729); Linn. Sp. Pl., 1 ed., 2, p. 1131 (1753); Hook. Brit. Jung. (1816). Candollea, sect. A., Raddi, in Att. Soc. Modena, 18, p. 22 (1818). Martinellia, sect. *b*, in Gray's Nat. Arr. Br. Pl. 1, p. 692 (1821). Radula, Dumort. Comm. Bot. p. 112 (1823). Plagiochila, Dum. Recueil, 1, p. 14 (1835); Lindenb. Sp. Hep. fasc. 1, 1–5 (1839); G. L. et N. Synop. Hep. p. 22 (1844).

Involucral bracts two, larger than the cauline leaves. Colesule compressed at the mouth, ciliate-dentate. Antheridia in the angles of perigonial leaves. Inflorescence autœcious or diœcious.

1. *Plagiochila asplenioides* (Linn.), Dumort. Stems ascending. Leaves subimbricated, obovate-rotund, ciliate-dentate, slightly recurved at apex. Colesule longer than the involucral bracts, compressed, oblique, mouth truncate or ciliated.

Jungermannia asplenioides, Linn. Sp. Pl. p. 1597; Engl. Bot. 1061; Hook. Brit. Jung. t. 13; Nees, Europ. Leber. 1, p. 161. Plagiochila asplenioides, Dumort. Rev. Jung. p. 14; G. L. et N. Synop. Hep. p. 49; Gottsche and Rabenhor. Hep. Eur. exsic. nos. 271–320; Carring. Brit. Hepat. p. 55, pl. 4, fig. 12; Cooke, Brit. Hepat. p. 5, fig. 37; Dumort. Hep. Europ. p. 43.

Hab. Banks among moss, and in woods. This, one of the largest and finest of the British species, is common all over Ireland. In the moist shady woods at Cromaglaun, it grows to a very large size, where the stems not unfrequently attain from 8 to 10 inches long.

Var. β. minor (*Plag. Dillenii*), Taylor, in Hook. Journal of Botany, p. 260; Trans. Bot. Soc. Edinb., 2, p. 16. Dumortier enumerates and describes this as a distinct species in Hepat. Europ., p. 43. It grows plentifully in the Killarney woods.

Var. δ. devexa, Ross Bay and Dingle Bay, Kerry, Dr. Carrington.

2. *Plagiochila spinulosa* (Dicks.), Dumort. Stems creeping, branches ascending. Leaves ovate, recurved, oblique, spreading, wedge-shaped, dentate-spinulose on ventral aspect and apex, entire on dorsal margin. Fructification lateral. Colesule roundish, compressed, the mouth truncate-ciliated.

Jungermannia spinulosa, Dicks. Crypt., fasc. 2, p. 14; Hook. Brit. Jung. t. 14; Engl. Bot. t. 2228; Taylor, Fl. Hib. 2, p. 58. Plagiochila spinulosa, Dumort. Rev. Jung. p. 13, p. 15, et Hepat. Europ. p. 44; Lindenb. Sp. Hep. p. 6, t. 1; G. L. et N. Synop. Hepat. p. 25; Carring. Brit. Hepat. p. 59, pl. 4, fig. 14. Martinellius spinulosus, B. Gray, in Gray's Nat. Arr. Brit. Pl. 692.

Hab. Woods and moist banks. This common species extends over the whole of Ireland, and is of frequent occurrence.

Var. γ. Carring. Brit. Hepat. p. 60. Glengarriff and Cromaglaun, Dr. Carrington.

3. ***Plagiochila punctata***, Taylor. Diœcious. Stems closely tufted, of a yellowish-green colour. Leaves variable in size and shape, rigid, and very caducous, especially after drying, those on the main shoots broadly ovate, convex, decurrent, upper margin and apex a little recurved, fringed with spinose teeth. On the ultimate branches the leaves are narrower, scarcely wider than the stem, cuneiform and spreading, their margins beset with from two to five distant teeth. Cells largely collenchymatous, very smooth, punctate—Dr. Taylor describes their appearance, "as if coarsely powdered;" Lindberg, as "verrucolosis striatulis." Colesule broadly ovate, from a narrow base, compressed at length, cleft at side, mouth open, beset with long spinulose teeth.

Plagiochila punctata, Taylor, in London Journal of Bot. 1844, p. 371 (sub. n. 10), et 1846, p. 261; Trans. Bot. Soc. Edinb., p. 179; G. L. et N. Synop. Hep. p. 626; Dumort. Hep. Eur. p. 45, n. 7; Gottsche et Rabenhor. Hep. Eur. exsic. n. 211; Lindb. in Acta Societatis Scientiarum Fennicæ, x., p. 524. Plagiochila spinulosa, β. punctata, Carring. Irish Crypt. p. 19, t. 2, f. 3 (1863), et Brit. Hepat. part 3, p. 60.

Hab. Shady woods, and banks among heath. Abundant in the Co. Kerry, especially in the Killarney woods, but not common in the northern or eastern counties. Altadore glen, and at Seven Churches, Wicklow; Glenad, Co. Leitrim.

It will be seen from the authors quoted, that considerable diversity of opinion exists as to the right of this plant to rank as a distinct species. Dumortier and Lindberg hold it to be a species, while Carrington considers it only as a variety of P. spinulosa. I have long known its habit, and have collected it in widely different habitats, where the principal characters have been constant. I have sometimes considered it nearer to P. tridenticulata than to P. spinulosa.

4. ***Plagiochila tridenticulata***, Taylor. Stems decumbent, ascending at apex, flexuose, slightly branched. Leaves distant, wedge-shaped, two to three times toothed at apex. Andrœcium spicate.

Jungermannia spinulosa, β. tridenticulata, Hook. Brit. Jung. p. 9, t. 14; Taylor, in Fl. Hib. 2, p. 58, n. 10, var. minuta. Plagiochila tridenticulata, Dumort. Rev. Jung. p. 15, et Hepat. Europ. p. 43; G. L. et N., Synop. Hep. p. 26; Carring. Brit. Jung. part 3, p. 63, pl. 3, fig. 10.

Hab. Moist ground, among the larger mosses, &c. This pretty and distinct species is mostly confined to the southern counties in Ireland, and is generally scattered in small tufts among other herbage. Cromaglaun, Dr. Taylor and Dr. Carrington. Brandon and Connor Hill, Kerry.

5. *Plagiochila exigua*, Taylor. Stems straggling, ascending, slightly branched, crowned with minute capituli, which at length elongate into new shoots. Leaves round-obovate, remote, patent, the lower bifid, nearer the apex trifid, or ciliate. Fructification unknown.

Jungermannia exigua, Taylor, in Trans. Bot. Soc. Edinb. 1, p. 179; Carring. Brit. Jung. pl. 4, fig. 13 (good). Plagiochila exigua, G. L. et N. Synop. Hep. p. 659; Dumort. Hepat. Europ. p. 46; Carring. Brit. Hepat. pl. 4, fig. 13; Cooke, Brit. Jung. p. 5, fig. 48 (bad).

Hab. About the bases of moss-covered trees at Cromaglaun and Killarney, where it was discovered by Dr. Taylor, who described it in 1843. At same place, 1873, where it is not rare; O'Sullivan's Cascade, and Glena, 1875. This singular and very minute plant is most likely to be observed when some of the larger kinds are under microscopical examination; among many of these it frequently makes its appearance in the Killarney gatherings. The stems are seldom more than one-fourth of an inch long, being more or less clothed with small, distantly-set leaves, which increase in size as they approach the apex of the stem.

MYLIA, Bennett, Gray.

Jungermannia, Hook. Brit. Jung. p. 15, n. 46, 47 (1816); Dumort. Recueil, 1, p. 16, n. 16 (1835). Mylia, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 693 (1821). Leptoscyphus, Mitt. in Hook. Lond. Journ. Bot. 3, p. 358 (1851). Coleochila, Dumort. Hepaticæ Europæ, p. 105 (1874).

Involucre oligophyllous, bracts connate at the base. Colesule terminal (or, from the growth of innovations, axillary), cylindrical, compressed at the apex, mouth cleft.

1. *Mylia Taylori* (Hook.), B. Gray. Diœcious. Stems ascending, slightly branched. Leaves 2-ranked, succubous, roundish, concave, reticulations large. Amphigastria subulate. Colesule ovate, slightly compressed at the mouth, truncate, deeply cleft in a bilabiate form. Antheridia in the axils of perigonial leaves.

Jungermannia Taylori, Hook. Brit. Junger. t. 34; Engl. Bot. t. 2318; Lindenb. Synop. Hepat. p. 24; Dumort. Syll. Jung. p. 48;

Taylor, in Fl. Hib. p. 2, p. 63; G. L. et N. Synop. Hepat. p. 82. Coleochila Taylori, Dumort. Hepat. Europ. p. 107.

Hab. On wet banks in subalpine parts of the country. This fine species frequently grows in large patches among heath. On the damp ground near mountain rivulets, where its purple-coloured tops attract the eye of the collector, even when at a considerable distance from the plant.

2. ***Mylia anomala*** (Hook.), B. Gray. Diœcious. This form, with the leaves varying from roundish concave to nearly acuminate, generally grows among Sphagnum. The late Dr. Taylor did not consider it was even a variety. Dr. Carrington thinks differently, and describes in his Irish Hepaticæ a character by which it may be distinguished from M. Taylori. He states, "the cells are of a different form from M. Taylori, containing curious fusiform corpuscles." Dumortier, in Hepaticæ Europæ, p. 106, gives it the rank of a species. I have found both forms frequently growing together, and so closely resembling each other, that it became a difficult task to separate them.

JUNGERMANNIA, Linneus.

Jungermannia, L. Fl. Suec., 1 ed., p. 338 (1745); Raddi, in Att. Soc. Modena, 18, p. 25 (1818); Gray's Nat. Arr. Brit. Pl. 1, p. 695 (1821); Dum. Comm. Bot. p. 113 (1823). Nitophyllum, Neck. Elem. Bot. 3, p. 336 (1790). Jungermannia, sect. 1, Diplophyllum, Dum. Syll. Jung. Eur. p. 44 (1831); sect. 3, Aplozia, do. p. 47; sect. 4, Gymnocolea, do. p. 52; sect. 5, Lophozia, do. p. 53; sect. 7, Cephalozia, do. p. 60. Diplophyllum, Dum. Recueil, 1, p. 15 (1835); Gymnocolea, do. p. 17 (1835); Lophozia, do. p. 17 (1835) (excl. L. scutata); Cephalozia, do. p. 18 (1835), (sola C. capitata); Marsupella, do. p. 24 (sola M. Mülleri) (1835). Liochlæna, Nees, in G. L. et N. Syn. Hep. p. 150 (1845). Solenostoma, Mitt. in Journ. L. Soc. 8, p. 51 (1864).—Lindberg.

Section A. APLOZIA.

Involucre oligophyllous. Leaves undivided, entire. Colesule sessile, erect, round or angular, mouth denticulate.

1. *Jungermannia* (*A.*) *cuneifolia* (Hook.), Dumort. Stems creeping. Leaves distant, cuneiform, entire or bluntly emarginate at the apex. Amphigastria minute, bifid.

Jungermannia cuneifolia, Hook. Brit. Junger. t. 64; Engl. Bot. suppl. t. 2700; G. L. et N. Synop. Hepat. p. 153.

Hab. Parasitic on the larger Hepaticæ, especially Frullania tamarisci. Bantry, Miss Hutchins. Torc Mountain, Dr. Carrington. On the stems of trees, creeping over F. tamarisci, between the police barrack and Upper Lake, Killarney. This singular minute species appears to be confined to the Killarney district of Kerry. It may, probably, turn out to be a Harpanthus when the fruit is found?

2. *Jungermannia* (*A.*) *crenulata*, Smith (Dumort.). Stems prostrate, branched. Leaves orbicular, bordered with large marginal cells. Colesule obovate, compressed, angled, mouth contracted, toothed.

Jungermannia crenulata, Sm. Engl. Bot. t. 1463; Hook. Brit. Jung. t. 37; Lindenb. Synop. Hepat. p. 66; G. L. et N. Synop. Hepat. p. 90; Taylor, Fl. Hib. 2, p. 58. Aplozia crenulata, Dumort. Hepat. Europ. p. 57 (1874).

Hab. On moist clay banks in woods, and on heaths. Not unfrequent through Ireland. Kelly's Glen, Dublin; side of the river, Seven Churches, Wicklow; Connemara; Ross Bay, Kerry, Dr. Carrington.

Var. β. gracillima, Jungermannia gracillima, Sm. Engl. Bot. t. 2238; Hook. Brit. Jung., at descript. n. 37. J. genthiana, Hüben. Hepat. Germ. p. 107. Aplozia gracillima, Dumort. Hepat. Europ. p. 57.

This variety, which is described and held as a species by some authors, gradually approaches the typical form of the plant in some of its states. It is, however, usually of smaller size, with the leaves more distantly placed on the stem, and more amplexicaul at their base. It occurs in similar places as that of the larger state of the plant, but at Westaston, Co. Wicklow, the var. β. is abundant, and none of the true A. crenulata grows with it.

3. *Jungermannia* (*A.*) *pumila* (With.), Dumort. Stems ascending, short, sub-simple. Leaves oblong-elliptic, concave. Colesule terminal, fusiform, plicate, dentate, ciliate at the mouth.

Jungermannia pumila, Wither, Bot. An., ed. 3, p. 866; Hook. Brit. Jung. t. 17; Sm. Engl. Bot. t. 2230; Tayl. Fl. Hib. 2, p. 58. Aplozia pumila, Dumort. Hepat. Europ. p. 59.

Hab. On rocks at the sides of streams and rivers, not rare, Dr. Taylor. Glen near the Hunting Tower, Cromaglaun, Dr. Carrington. Connor Hill and glen at Brandon, Kerry; Lough Bray, Co. Wicklow; Glenad, Co. Leitrim.

4. *Jungermannia* (*A.*) *cordifolia* (Hook.), Dumort. Stems erect, branching. Leaves incumbent, cordate, concave, amplexicaul. Fruit terminal and axillary. Colesule plicate, mouth contracted, denticulate. Antheridia in the axils of perigonial leaves, spherical, reticulated.

Jungermannia cordifolia, Hook. Brit. Jung. t. 32; Engl. Bot. t. 2590; Lindenb. Synop. Hepat. p. 72; G. L. et N. Synop. Hepat., p. 93; Tayl. Fl. Hib. 2, p. 58; Rabenhor. Hepat. Europ. exsic. nos. 271–344. Aplozia cordifolia, Dumort. Hepat. Europ. p. 59.

Hab. Moist banks, and on the rocky bottoms of rivers and streams. Mangerton, Co. Kerry, in the stream from the Punch Bowl, Dr. Taylor. River which flows down to Cushindun, Co. Antrim, three-quarters of a mile above the village, 1836. Coomashana lake, Kerry, Dr. Carrington. Brandon, 1864. Maghanabo glen, Kerry, 1875, D. Macardle. This distinct and well-marked species is rather rare in Ireland.

5. *Jungermannia* (*A.*) *sphærocarpa* (Hook.), Dumort. Stem simple, ascending. Leaves rather distant, accumbent, orbicular, entire. Colesule terminal, obovate, contracted at the mouth and cut into four large teeth.

Jungermannia sphærocarpa, Hook. Brit. Junger. t. 74; Lindenb. Synop. Hepat. p. 68; Fl. Dan. t. 1773; G. L. et N. Synop. Hepat. Europ. p. 93; Tayl. Fl. Hib. 2, p. 58. Aplozia sphærocarpa, Dumort. Hepat. Europ. p. 61.

Hab. On stones by the sides of rivulets. Near Dublin, and at Torc Waterfall, Killarney, Dr. Taylor. Kelly's glen, Dublin; Lough Bray, Wicklow; wet rocks, Glenad, Co. Leitrim.

6. *Jungermannia* (*A.*) *riparia* (Taylor), Dumort. Stems procumbent, slightly branched. Leaves obovate, obtuse, closely set on the stem, and subamplexicaul, concave, entire. Colesule terminal, obovate, apex plicate.

Jungermannia riparia, Taylor, in Trans. Bot. Soc. Edin. p. 43; G. L. et N. Synop. Hepat. p. 97; Cogn. Hepat. Belg. p. 28; Cooke's Brit. Jung. p. 9, fig. 69. Aplozia riparia, Dumort. Hepat. Europ. p. 63.

Hab. Sides of streams and pools. Kerry, Dr. Taylor. Benbulben, Sligo; Brandon, Kerry; Loughbray, and near Woodenbridge, Wicklow. Torc Cascade, Dr. Carrington. Enniscona, Cork, Isaac Carroll, Esq. Dr. Taylor remarks that this plant has been freqaently mistaken for J. pumila. When strong it is more likely to be overlooked at first sight for Chiloscyphus polyanthos.

7. *Jungermannia* (*A.*) *nana*, Nees. Stems ascending or erect, pale green, radiculose, branches slender. Leaves round or roundish-ovate, erect, clasping. Colesule obtuse, at length quadrangular and slightly crested, mouth toothed.

Jungermannia nana, Nees, Hep. Europ. 1, pp. 317, 278; 2, p. 466; 3, p. 533; 4, p. 41; Gottsche, Ic. Hep. ined. Jungermannia pumila, Lindenb. Hep. Europ. p. 69, n. 68, t. 2 (excl. synon.); De Notar., Prim. Hep. Ital. p. 38, n. 48; G. L. et N. Synop. Hepat. Europ. p. 91; Carring. Irish Hepat., Trans. Bot. Soc. Edinb. vol. 7, p. 3, p. 448. Jungermannia lurida, Dumort. Hepat. Europ. p. 60 (1874). Var. *a* major, Jungermannia lurida, Dumort. Syll. p. 50, n. 49 (1831).

Hab. On wet banks, by the sides of streams. Glengariff, Co. Cork, Miss Hutchins. Kelly's glen, Co. Dublin, and near the Seven Churches, Co. Wicklow. Apparently rare in Ireland. This little plant is in every way nearly allied to Jungermannia crenulata and J. gracillima. The trigonal colesule, partly crested in these plants, accords with the character of Lindberg's section *a*, Eucalyx, in his genus Nardia (emend.). I, however, consider them more naturally placed where Dumortier has placed them—in his section Aplozia, with J. sphærocarpa, J. pumila, &c.

Section B. SPHENOLOBUM.

8. ***Jungermannia*** (*S.*) ***Dicksoni***, Hook. Stems ascending, mostly simple. Leaves unequally 2-lobed, lobes narrow, ovate, acute, entire at the margin, ventral lobe much the largest. Colesule terminal, slightly plicate, and subciliate at the mouth. Antheridia in the axils of perigonial leaves.

Jungermannia Dicksoni, Hook. Brit. Jung. t. 48; Engl. Bot. 2591; Taylor, in Fl. Hib. p. 2, p. 62; Ekart, Synop. Jung. p. 52, tab. 9, fig. 68; G. L. et N. Synop. Hep. p. 79. Diplophyllum Dicksoni, Dumort. Rev. Jung. p. 16, et Hepat. Europ. p. 49 (1875); Cogn. Hepat. Belg. p. 24.

Hab. On rocks and moist banks in subalpine parts of Ireland. Rare. Mountains near Dublin, Dr. Taylor. Loughbray, Co. Wicklow, single stems; Gleniff, Leitrim, single stems; north side of Connor Hill, Kerry, single stems, growing among the larger mosses.

9. ***Jungermannia*** (*S.*) ***minuta***, Crantz. Stems erect, dichotomously branched. Leaves patent, bilobed, lobes nearly equal, acute at the apex, margins entire. Colesule terminal, subspherical, mouth contracted, denticulate. Antheridia in the axils of perigonial leaves, several together, spherical, reticulated.

Jungermannia minuta, Crantz. Hist. Græn. p. 288; Hook. Brit. Jung. t. 44; Sm. Engl. Bot. t. 2231; G. L. et N. Synop. Hep. p. 120; Taylor, in Fl. Hib. p. 2, p. 62. Diplophyllum minutum, Dumort. Rev. Jung. p. 16, et Hepat. Europ. p. 49; Cogn. Hepat. Belg. p. 24.

Hab. Heathy and rocky banks; rare in fruit. Loughbray, Co. Wicklow; also at Seven Churches, Wicklow.

Section C. LOPHOZIA, Dumortier.

Involucre oligophyllous, multifid, dissimilar to stem leaves. Colesule sessile, erect, round, inflated, contracted at the mouth, and dentate.

(*A.*) *Stipulatæ.*

10. ***Jungermannia*** (*L.*) ***Bantriensis***, Hook. Stems subsimple, erect or ascending. Leaves roundish-oval, emarginate or bidentate at the apex. Amphigastria minute, entire, or slightly toothed on the margin. Colesule obovate, dentate at the mouth.

Jungermannia Bantriensis, Hook. Brit. Jung., in annotatione ad J. stipulaceam, species 41; Nees, Europ. Leberm. 2, p. 24, and 3, p. 540; G. L. et N. Synop. Hep. p. 100; Rabenhor. Hep. exsic. n. 305; Cooke, Br. Jung. p. 10, fig. 70; Dumort. Hep. Europ. p. 68.

Hab. Bantry, Miss Hutchins. Glengariff, Dr. Carrington. Brandon, Kerry; Benbulben, Sligo; Gleniff, Leitrim.

11. *Jungermannia* (*L.*) *Hornschuchiana*, Nees. Stems subsimple, diffuse. Leaves suborbiculate, bidentate, sinus shallow, lobes rather acute. Amphigastria bifid, divisions lanceolate, ciliate-dentate at base. Colesule long, cylindrical, mouth acute, gradually approaching to triangular.

Jungermannia Hornschuchiana, Nees, Europ. Leberm. 2, p. 153; G. L. et N. Synop. Hepat. p. 101; Husnot, Hepat. Gall. n. 32.

Hab. Wet places in subalpine parts of the country. At Cromaglaun, Co. Kerry, and among rocks near Torc Mountain, July, 1869; stream near Woodenbridge, Co. Wicklow. This plant is rather larger than most of those in same section, and might be easily passed over for J. (A.) riparia, both in a fresh and dried state. It is only when the peculiarly notched sub-vertical leaves with their amphigastria are examined, that its distinguishing characters are observed. Dr. Lindberg considers J. Hornschuchiana, J. Bantriensis, and J. Mülleri forms of one species.

12. *Jungermannia* (*L.*) *Orcadensis*, Hook. Stems erect. Leaves closely imbricated, erecto-patent, incumbent, appressed, cordate-ovate, margins recurved, obtusely emarginate at apex.

Jungermannia Orcadensis, Hook. Brit. Jung. t. 71; Lindenberg, Syn. Hep. p. 74; Nees, Eur. Leberm. 2, p. 35; G. L. et N. Synop. Hep. p. 107; Gottsche et Rabenhor. Hep. Eur. exsic. n. 40, 399, 400; De Notar. Prim. Hep. Ital. p. 32. Mesophylla Orcadensis, Dumort. Syll. Jung. p. 80; Hepat. Europ. p. 130.

Hab. Among the larger mosses and Hepaticæ in subalpine parts of the country, but very rare in Ireland. Brandon, Co. Kerry. "Connor Hill, among Herberta adunca, Dr. Lindberg (1873)."

13. *Jungermannia* (*L.*) *barbata*, Schreber. Stems ascending, slightly branched. Leaves subquadrate, 3–5 cleft. Amphigastria acutely bifid, and laciniated. Colesule ovate, contracted at the mouth, and toothed. Antheridia in the axils of perigonial leaves, round, greyish, and slightly reticulated.

Jungermannia barbata, Schreber, Spicil. Lips. p. 107; Schmidel, Icones, p. 187; Hook. Brit. Jung. n. 70; Dumort. Syll. Jung. p. 58; Hepaticæ Europæ, p. 72 (1874). J. quinquidentata, Huds. Angl. Fl. p. 511; Schwaegr. Prodr. Hepat. p. 29; Sm. Engl. Bot. t. 2547; Lindenb. Synop. Hepat. p. 45; Ekart, Syn. n. 47, tab. 5, fig. 41; De Not. Prim. Hep. Ital. p. 22. Lophozia barbata, Dum. Rev. Jung. p. 17; Cogn. Hepat. Belg. p. 31.

Hab. Among rocks, and on heathy banks. This plant is of general occurrence in Ireland, from the northern to the southern counties, and from east to west; but most abundant in the north, especially in counties Antrim and Donegal.

Var. β. Floerkii. Leaves connivent. Amphigastria long and laciniate. Jungermannia Floerkii, Web. et Mohr, Deutschl. Crypt. p. 410; Mart. Erlang. p. 144, t. 4, f. 17. Muckish, Donegal.

(*B.*) *Ex-stipulatæ.*

14. *Jungermannia* (*L.*) *Lyoni*, Taylor. Stems ascending, sparingly branched. Leaves alternate, distichous, subquadrate, recurved, trifid, anterior laciniæ roundish, posterior reflexed, all acute or incised, terminal tooth large. Amphigastria wanting. Involucral bracts rather long. Colesule oblong, obtuse, inflated at the base near to the middle, mouth plicate-ciliate.

Jungermannia Lyoni, Taylor, in Trans. Bot. Soc. Edinb. 1, p. 116, tab. 7; Spruce, in Trans. Bot. Soc. Edinb. 3, p. 204; Dumort. Hepat. Europ. p. 73 (1874). J. socia, var. γ., G. L. et N. Synop. Hep. p. 112. J. barbata var. G. L. et N. *l. c.* p. 678.

Hab. On rocky banks among mosses. At Glenmaluer, Co. Wicklow, among tufts of Scapania resupinata, single stems. It will be observed from the foregoing quotations, that considerable diversity of opinion prevails regarding the position this plant ought to occupy, whether as a species, or only as a variety of J. barbata. Dr. Spruce's critical observations, which always deserve the greatest attention, would appear to be decisive on the point, namely, that it is a good species. He never found the true J. barbata in the Pyrenees, though he found J. Lyoni.

15. *Jungermannia* (*L.*) *exsecta*, Schmidel. Stems prostrate. Leaves 2-ranked, spreading, ovate-lanceolate, bilobed, and cut at the margin, lobes very unequal, sharp at apex. Involucral bracts quadrifid. Colesule terminal, plicate.

Jungermannia exsecta, Schmid. Ic. et Anal. p. 241, t. 62, fig. 2, excl. fig. fructf. et 19, 20; Hook. Brit. Jung. t. 19, and suppl. t. 1; Taylor, in Fl. Hib. p. 2, p. 62; G. L. et N. Synop. Hepat. p. 77; Gottsche et Rabenhor. Hep. Eur. exsic. n. 130, 358; Dumort. Hepat. Europ. p. 73.

Hab. Banks, and in old woods. Bantry, Co. Cork, Miss Hutchins. On dry banks common, Dr. Taylor. Rotten bogs, Cromaglaun, Dr. Carrington. Ballinhassig glen, Co. Cork, Isaac Carroll, Esq. Gleniff, Leitrim; Sillaghbraes, Antrim.

16. *Jungermannia* (*L.*) *intermedia*, Lindenb. Stems ascending, slightly branching. Leaves in two rows, erect, roundish in outline, bifid segments acute. Involucral bracts 3–5 lobed, inciso-dentate, connate at base, appressed. Amphigastria wanting. Colesule terminal, obovate.

Jungermannia excisa, var. crispa, Hook. Brit. Jung., p. 11, tab. suppl. 2. Jungermannia bicrenata, var. minor, Mart. Fl. Crypt.

Erlang., p. 168. Jungermannia intermedia, Lindenb. Synop. Hepat., p. 83; Dumort. Syll. Jung. p. 55; Ekart, Synop. p. 15, tt. 6, 12, fig. 46; Nees, Europ. Leberm., 2, p. 125; Gottsche et Rabenhor. Hep. Eur. exsic., n. 60, 144, 312; Dumort. Hepat. Europ. p. 76. Lophozia intermedia, Dumort. Rev. Jung. p. 17.

Hab. Bogs and banks in subalpine parts. On Galtymore Mountain, Co. Tipperary.

17. *Jungermannia* (*L.*) *capitata*, Hook. Stems prostrate, rather crowded. Leaves erect, roundish-quadrate in outline, the lower bifid, the upper crowded, resembling involucral bracts, 3-5 incised, and cleft. Amphigastria wanting. Colesule terminal, oval.

Jungermannia capitata, Hook. Brit. Jung. t. 80. Jungermannia intermedia, var. capitata, Nees, Europ. Leberm., 2, p. 125.

Hab. Dry mountain rocks. Near Bantry, Miss Hutchins, who sent it to Hooker. (Brit. Jung., n. 80). Some of the best authorities on British Hepaticæ consider this and the previous-named species to be the same. I am not well acquainted with either.

18. *Jungermannia* (*L.*) *ventricosa*, Dicks. Stem ascending, slightly branched. Leaves accumbent, subquadrate, obtuse or bluntly emarginate, concave. Involucral bracts 3-4 cleft. Amphigastria wanting. Colesule ovate-oblong, contracted at the mouth and slightly toothed.

Jungermannia ventricosa, Dicks. Pl. Crypt. 2, p. 14; Hook. Brit. Jung. t. 28; Engl. Bot. t. 2568; Tayl. in Fl. Hib. 2, p. 60; G. L. et N. Synop. Hepat. p. 108; Rabenhor. Hepat. Europ. exsic. n. 184, 185.

Hab. Banks and rocks in mountain situations, Dublin and Wicklow. Conemore, Dr. Taylor. Antrim; Benbulben, Sligo; Galtymore, Tipperary. Rare at Killarney, Dr. Carrington.

19. *Jungermannia* (*L.*) *excisa*, Dicks. Stem prostrate. Leaves patent, subquadrate, deeply emarginate. Fruit terminal. Colesule oblong-ovate, the mouth wide, plicate, and toothed.

Jungermannia excisa, Dicks. Pl. Crypt. 3, p. 11, t. 8, fig. 7; Hook. Brit. Jung., p. 11 (excl. syn. Mohr, Wahlen., Schwægr., and Smith; also var. which is in Suppl. t. 2); Lindenb. Synop. Hep. p. 84; Nees, Europ. Leberm. 2, p. 98; G. L. et N., Synop. Hep. p. 112; Dumort. Hepat. Europ. p. 78. Lophozia excisa, Dumort. Rev. Jung., p. 17.

Hab. Woods and heathy banks. Rare in Ireland. On the mountains near Dublin, Dr. Taylor. This plant has not turned up among the widely extended gatherings made by me in many parts of Ireland, nor have I seen Irish specimens of it.

20. *Jungermannia* (*L.*) *bicrenata*, Lindenb. Stems procumbent, subsimple. Leaves roundish-ovate, acutely emarginate. Involucral bracts

appressed, trifid, sub-serrulate. Amphigastria wanting. Colesule ovate.

Jungermannia bicrenata, Lindenb. Synop. Hepat. p. 82; Nees, Europ. Leberm. 2, p. 119; G. L. et N. Synop. Hepat., p. 115; Dumort., Hepat. Europ., p. 78. Jungermannia excisa, Sm. Engl. Bot. t. 2497 (excl. syn.); Ekart, Synop. Jung. t. 11, fig. 93.

Hab. On the ground among heath, and on shady banks. Temple Michael, Cork, Isaac Carroll, Esq.; near Letterfrack, and Kylemore, Co. Galway (1874).

21. *Jungermannia* (*L.*) *incisa*, Schrader. Stems prostrate, subsimple. Leaves accumbent, roundish-quadrate, undulate, trifidly cut, the segments unequal. Involucral bracts 3-4 incised. Amphigastria wanting. Colesule terminal, obovate, mouth toothed.

Jungermannia incisa, Schrader, Samml., 2, p. 5; Hook. Brit. Jung. t. 10; Engl. Bot. t. 2528; G. L. et N. Synop. Hepat. p. 118; Dumort. Syll. p. 56; Hepat. Europ. p. 80; Taylor, in Fl. Hib. 2, p. 61. Lophozia incisa, Dumort. Rev. Jung. p. 17; Cogn. Hepat. Belg. p. 30.

Hab. On the wet sides of turfy banks. Rare on the eastern and northern sides of Ireland; more abundant on the western, particularly in Connemara; Corslieve Mountain, and Bengore, Mayo; near Kylemore, Galway; abundant on the top of Mulrea Mountain, Mayo. Near Cooneashana lake, Kerry, Dr. Carrington.

Section D. GYMNOCOLEA, Dumortier.

Involucre oligophyllous, bracts bifid. Colesule pedunculate, mouth denticulate.

22. *Jungermannia* (*G.*) *laxifolia* (Hook.), Dumort. Stem lax, filiform, prostrate. Leaves remote, ovate, acutely bifid, segments acute, erect. Colesule subterminal, often from the axil of a young branch, subplicate, mouth contracted, denticulate.

Jungermannia laxifolia, Hook. Brit. Jung. t. 59; Engl. Bot. t. 2677; Lindenb. Synop. Hepat. p. 34; Taylor, in Fl. Hib. p. 65; G. L. et N. Synop. Hepat. p. 147; Rabenhor. Hep. Europ. exsic. n. 343. Gymnocolea laxifolia, Dumort. Rev. Jung. p. 17, et Hepat. Europ. p. 64.

Hab. On rocks by the sides of rivulets. Near Bantry, Miss Hutchins. Castlekelly Mountain, Dublin, and Aooreagh river, near Sneem, Kerry, Dr. Taylor. Maghanabo glen, Connor Hill, and Brandon, Kerry. Cromaglaun and Mangerton, Dr. Carrington. This minute plant adheres closely to the rocks on which it grows, and looks more like a minute Alga than a Hepatic.

23. ***Jungermannia* (*G.*) *inflata*** (Huds.), Dumort. Stem ascending, branched. Leaves 2-ranked, acutely bifid, the segments obtuse. Colesule terminal, oblong-ovate, mouth contracted and toothed.

Jungermannia inflata, Huds. Flor. Angl. p. 511; Hook. Brit. Jung. t. 38; Lindenb. Synop. Hepat. p. 79; De Notaris, Prim. Hepat. Ital. p. 29; Taylor, in Fl. Hib. 2, p. 59; G. L. et N. Synop. Hepat. p. 105; Rabenhor. Hepat. Europ. exsic. n. 174–311, &c. Gymnocolea inflata, Dumort. Rev. Jung. p. 17, et Hepat. Europ. p. 63.

Hab. On stones by rivulets; but oftener on moors about the roots of heath. Bantry, Miss Hutchins. Abundant on the moors at Featherbed Mountain, Co. Dublin. Near Finglas, Dublin, Mr. D. Macardle.

Var. a. compacta, Carrington. On the top of Howth Hill, Dublin, where it grows among dry rocks and is green, not having the usually black colour of the species.

Var. γ. laxa. Near Lough Guitane, and near Dean Bridge. Ross Bay, Kerry, Dr. Carrington.

24. ***Jungermannia* (*G.*) *affinis*** (Wilson), Dumort. Stem small, procumbent. Leaves rounded, concave, bifid, segments obtuse, reticulation large and hyaline. Involucral bracts larger than the cauline leaves, spreading, and slightly reflexed. Colesule terminal, pyriform, contracted, plicate, and toothed at the mouth.

Jungermannia affinis, Wilson, in Hook. Brit. Fl. 2, p. 128. Jungermannia turbinata, Wils. in Engl. Bot. suppl. t. 2744, nec Raddi; Taylor, in Fl. Hib. 2, p. 59. Jungermannia Wilsoniana, Nees, Europ. Leberm. 3, p. 548; Cooke, Brit. Jung. p. 10, f. 74. Gymnocolea affinis, Dumort. Hepat. Europ. p. 65.

Hab. Woodlands, near Dublin, W. Wilson, Esq., 1830. Not unfrequent on the grey limestone in the Co. Dublin, where it fruits freely. Finglas quarry, Mr. D. Macardle. On white limestone near Glenarm, Co. Antrim. Killarney, on limestone, Dr. Carrington. Torc Cascade, Killarney, and a larger state of the plant on Carrantual, Kerry.

NARDIA, Bennett, Gray.

Jungermannia, Ehrh. in Hann. Mag. p. 141 (1784); Schrad. Syst. Samml. Krypt. Gew. 2, p. 4 (1797); Sm. Engl. Bot. tab. 1463 (1805); Hook. Brit. Jung. (1816). Nardia, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 701 (1821); Lindb. in Act. Soc. Sc. Fenn. x., p. 115 (1871); sect. 1, Eucalyx, Lindb. in Bot. Not. (1872). Mesophylla, Dum. Comm. Bot. p. 112 (1823). Marsupella, Dum. Comm. Bot. p. 114 (1823), et Recueil, 1, p. 23, n. 37 (1835). Sarcoscyphus, Corda, in Opiz, Beitr. 1, p. 652 (1829); Sturm, Deutschl. Fl. 2, fasc. 19, 20 (1830). Alicularia, Corda, in Opiz, Beitr. 1, p. 652 (1829). Gymnomitrium, Nees, Nat. Eur. Leber. 1, p. 120 (1833); Solenostoma, Mitt. in Journ. Lin. Soc. 8, p. 51 (1864).

Section A. MARSUPELLA (Dum.), Lindberg.

Colesule connately united with the involucral leaves and torus, together forming an urceolate perianth. Capsule globose. Elaters with two spires. Antheridia in the saccate bases of the perigonial leaves.

1. *Nardia emarginata* (Ehrh.), B. Gr. Stem erect. Leaves distichous, imbricated, patent, obcordate, emarginate.

Jungermannia emarginata, Ehrh. Beitr. 3, p. 80; Sm. Engl. Bot. t. 1022; Hook. Brit. Junger. t. 27; Taylor, in Fl. Hib. 2, p. 59; Fl. Danica, t. 1945, f. 1. Nardius emarginatus, B. Gr. in Gray's Nat. Arr. Br. Pl. 1, p. 694. Marsupella emarginata, Dumort. Comm. Bot., p. 114; Rev. Jung. p. 24, et Hepat. Europ. p. 126. Sarcoscyphus Ehrharti, Corda, in Opiz, Natural., p. 652; G. L. et N. Synop. Hepat. p. 6; Nees, Eur. Leberm. 1, p. 125.

Hab. Wet rocks and sides of mountain rivulets. Very frequent in Ireland. Several distinct forms or varieties which retain their habits as to size, colour, &c., occur occasionally.

Var. γ. *minor* was found sparingly on rocks near the police barrack at Cromaglaun, in 1873.

2. *Nardia sphacelata*, Giesecke. Stem erect, branched. Leaves distichous, not so closely imbricated as in the previous species, patent, obovate-emarginate, rounded at the acute apex.

Jungermannia sphacelata, Giesecke, in Lindenb. Synop. Hep. p. 76, t. 1, fig. 9; Ekart, Synop. Jung. p. 15, tab. 11, fig. 91. Marsupia sphacelata, Dumort. Syll. Jung. p. 78. Sarcoscyphus sphacelatus, Nees, Europ. Leber. p. 129; G. L. et N. Synop. Hepat. p. 7; Rabenhor. Hepat. Europ. exsic. n. 519–255. Marsupella sphacelata, Dumort. Hepat. Europ. p. 127.

Hab. Wet rocks by the borders of mountain rivulets. Very rare. Loughbray, Wicklow, according to Dr. Carrington (British Hepaticæ, p. 12), who states that Dr. Lindberg collected it there in 1873, growing with Nardia compressa. I have never seen an Irish specimen of this plant, though Lindberg states, that it was collected by me at Loughbray, Wicklow.

3. *Nardia Funckii* (Web. et Mohr), Carring. Stem erect, densely tufted, slightly branched. Leaves distichous, obovate, rounded, concave, acutely emarginate.

Jungermannia Funckii, Web. et Mohr, Deuts. Krypt. p. 422; Lindenb. Synop. Hepat. p. 77; Ekart, Synop. Jung. p. 14, t. 13, fig. 112. Sarcoscyphus Funckii, Nees, Europ. Leberm. 1. p. 135; G. L. et N. Synop. Hepat. p. 8; Rabenhor. Hep. Europ. exsic. n.

86–254. Marsupella Funckii, Dumort. Rev. Jung. p. 24, et Hepat. Europ. p. 128.

Hab. On moist shady banks, and argillaceous rocky places. Black Mountain, near Belfast (1837); mountains above Kylemore lake, Co. Galway (1874).

4. *Nardia revoluta* (Nees), Lindb. Stem matted, flagilliferous at the base, densely tufted. Leaves obovate-elliptic, imbricated, semi-amplexicaul at the base, reflexed at the margin, acutely emarginate.

Sarcoscyphus revolutus, Nees, Leberm. Eur. 2, p. 419; G. L. et N. Synop. Hep. p. 8. Marsupella revoluta, Dumort. Hepat. Europ. p. 126. Nardia revoluta, Carring. Grevillea, n. 18, p. 88, fig. 19-25 (1873); Brit. Hepat. p. 22; Lindb. Revis. Crit. Fl. Dan. p. 113 (1871).

Hab. On rocks at Luggielaw, Wicklow, Mr. David Orr (1851). Not found by any other person in Ireland. This rare plant I collected in some quantity on rocks above Jerkin station, on the Dovrefield, Norway, in 1864.

Section B. Mesophylla, Dumortier.

5. *Nardia scalaris* (Schrader), B. Gr. Diœcious. Stem ascending, radiculose. Leaves two-ranked, accumbent, roundish, entire, or rarely subemarginate. Amphigastria broadly subulate. Involucre urceolate.

Jungermannia scalaris, Schrad. Samml. 2, p. 4; Hook. Brit. Jung. t. 61; Lindenb. Synop. Hepat. p. 28; Nees, Europ. Leberm. p. 281. Mesophylla scalaris, Dumort. Comm. Bot. p. 112; Rev. Jung. p. 24. Alicularia scalaris, Corda, in Opiz, Natural. p. 653; G. L. et N. Synop. Hep. p. 10; Gottsche et Rabenhor. Hep. Europ. exsic. n. 69, 70, 232–381; Dumort. Hepat. Europ. p. 131; Nardius scalaris, B. Gr. in Gray's Nat. Arr. Br. Pl. 1, p. 694, n. 1 (1821); Carrington, Brit. Hepat. p. 23.

Hab. On moist clay banks, among heath and other herbage. Very abundant throughout Ireland. It varies considerably in form according to the nature of some localities where it grows. A very remarkable form, the var. β. rivularis, Lindb., grows in very wet places under the constant spray of little cascades, or running water, where its clear glistening leaves are very conspicuous. It has frequently been named Jung. hyalina by some of our most acute and well practised hepaticists.

6. *Nardia compressa* (B. Gr.), Carrington. Stem erect, branched, laterally compressed. Leaves succubous, two-ranked, orbiculate, compressed, subulate. Amphigastria sometimes present at the points of young shoots. Calyx immersed among the involucral leaves, mouth toothed.

Jungermannia compressa, Hook. Brit. Jung. t. 58; Sm. Engl. Bot. t. 2587; Lindenb. Synop. Hep. p. 33. Mesophylla compressa, Dumort. Comm. Bot. p. 112; Syll. Jung. p. 80, t. 2, et Hepat. Europ. p. 129. Alicularia compressa, G. L. et N. Synop. Hep. p. 12; Rabenhor. Hepat. Europ. exsic. n. 443, 472, 537. Nardia compressa, Carrington, Brit. Hepat. pl. 3, fig. 9.

Hab. Sides of rivulets, and moist rocky places near waterfalls. Local in Ireland, and chiefly confined to the Co. Wicklow, on the east side, and Kerry on the south-west. First discovered by Miss Hutchins, near Bantry, Cork. At Aooreagh river, near Sneem, Dr. Taylor. Abundant at Upper Loughbray, more sparingly at Luggielaw and Seven Churches, Wicklow; Kelly's glen, Dublin; Connemara—near Kylemore, Galway.

Var. β. rigida, Lindb. Near to N. sphacelata, but stems shorter, narrower, and more rigid, more branched, more densely foliaceous, and here and there flexuose. Leaves more spreading and rigid. Cells twice the size, and thickened, generally highly coloured.

Hab. Loughbray, Co. Wicklow, Dr. Lindberg. On boggy land near Seven Churches, Co. Wicklow.

Dr. Lindberg states that this form is intermediate between the typical form of the species and its var. γ. Carringtonii; (Adelanthus Carringtonii, Balfour, MSS.; Nardia Carringtonii, Lindb. The first plants of this which I collected were sent to Dr. Lindberg, who named them N. Carringtonii without any reservation.

Section C. SOUTHBYA, Spruce.

7. *Nardia obovata* (Nees), Carrington. Stems ascending, clothed with purple rootlets. Leaves roundish, obovate, patent, base contracted and somewhat saccate, alternate on lower portion of stem, opposite at apex. Involucral leaves connate more than half way with the colesule, the upper portion of which is free, mouth toothed.

Jungermannia obovata, Nees, Europ. Leberm. 1, p. 332; 2, p. 474; G. L. et N. Synop. Hepat. p. 95, n. 44; Fl. Danica, suppl. t. 118, n. 2; Carring. Tr. B. Soc. Ed. 7, p. 447; Cooke, Brit. Jung. p. 8, fig. 62. Jungermannia tersa, Nees, Europ. Leberm. p. 471 (*ex parte*), et Synop. Hepat. p. 94 (*ex parte*). Southbya obovata, Dumort. Hepat. Europ. p. 133. Nardia obovata, Carring. Brit. Hepat. p. 32, pl. 11, fig. 35.

Hab. Moist rocks, and by the sides of rivulets. Torc Mountain, Killarney, W. Wilson (1829). Lough Bray, Co. Wicklow.

Var. β. minor, Cromaglaun, Killarney, Dr. Carrington, Irish Crypt. in Trans. Bot. Soc. Edinb. 7, part 3, p. 447, pl. 2, fig. 1. Connor Hill, Kerry; streams above Kylemore lake, Co. Galway.

8. *Nardia hyalina* (Lyell), Carrington. Polyœcious. Stem flexuose, creeping, ascending at the apex. Leaves roundish, subcrenulate

at the margin, erecto-patent, entire. Colesule subterminal, oblong, angulate, mouth contracted, toothed.

Jungermannia hyalina, Lyell, in Hook. Brit. Jung. tab. 65; Lindenb. Synop. Hepat. p. 67; Dumort. Syll. Jung. p. 50; G. L. et N. Synop. Hepat. p. 92; Cooke, Brit. Jung. p. 8, fig. 61; Engl. Bot. suppl. t. 2678. Aplozia hyalina, Dumort. Hepat. Europ. p. 58. Nardia hyalina, Carring. in Brit. Hepat. p. 35, pl. 11, fig. 36.

Hab. Moist banks, and by the sides of streamlets in rocky places. Seefing Mountain, Dublin. Aooreagh river, near Sneem, Kerry, Dr. Taylor, in Fl. Hib. Brandon, W. Wilson, Luggielaw, and Seven Churches, Wicklow. Not very common in Ireland.

ADELANTHUS, Mitten.

Jungermannia, Dicks. Pl. Crypt. (1783). Hook. Brit. Jung. (1816); Radula, sect. 3, Plagiochila, Dum. Syll. Jung. Europ. p. 43 (1831). Plagiochila, Dumort. Recueil, 1, p. 15 (1835). Gymnanthe, Mitten, in Journal Linn. Soc. p. 166 (1863). Adelanthus, Mitten, in Journal Linn. Soc. 7, p. 243 (1864). Odontoschisma, Lindb. Soc. Faun. et Fl. Fenn. 13, pp. 357–363 (1874).

Perianth on short ventral shoots at the base of the branches, tubulose, mouth connivent, subtrigonous, dentate. Involucral bracts trifarious. Antheridia in the axils of perigonial leaves which are spicate. Stems procumbent below, stoloniferous, leafless, branches erect, curved, simple. Leaves distichous, almost vertical, dorsal margin decurrent.

Adelanthus decipiens (Hook.), Mitten. Diœcious. Stem erect, the upper leaves subcompressed, larger, rotundate, the lower ovate, all of them marginate, reticulated with irregular spiniform teeth. Amphigastria thick, short, subulate. Colesule on short ventral shoots, tubulose, ventricose, mouth connivent, ciliate-dentate. Antheridia in the axils of perigonial leaves of the male plant.

Jungermannia decipiens, Hook. Brit. Jung. tab. 50; Engl. Bot. 2566; Nees, Hep. Eur. 1, p. 159. Plagiochila decipiens Dumort. Rev. Jung.; G. L. et N. Synop. Hepat. p. 24; Gottsche et Rabenhor. Hepat. Eur. p. 213. Lindenb. Spec. Hep. p. 51, n. 29, tab. 12, figs. 1–3. Radula decipiens, Dumort. Syll. Jung. p. 43, p. 15. Gymnanthe decipiens, Mitt., Journ. of Linn. Soc. 7, p. 166. Adelanthus decipiens, Mitt. in Journ. of Linn. Soc. 7, p. 244; Gottsche et Rabenhor. Hepat. Eur. exsic. n. 474 (cum icone) excellent.

Hab. Rocky and heathy places near Bantry (Miss Hutchins), Killarney, near Glengariff (Dr. Carrington). Glenad, Leitrim.

CESIA, Bennett, Gray.

Jungermannia, Lightfoot, Fl. Scot. 2, p. 786 (1770); Hook. Brit. Junger. (1816). Cesia, B. Gray, in Gray's Nat. Arr. Brit. Pl., 1, p. 705 (1821); Carruth. in Seem. Journ. Bot. 3, p. 300 (1865). Schisma, Dumort. Comm. Bot. p. 114 (1823). Gymnomitrium, Corda, in Opiz, Beitr. 1, p. 651 (1829); Nees, Nat. Eur. Leberm. 1, p. 113 (1833). Sect. 1, Julacea, G. L. et N. Synop. Hep. p. 2 (1844). Acolea, Dumort. Syll. Jung. Eur. p. 76 (1831), et Recueil, 1, p. 23 (1835).

Involucral leaves several. Colesule wanting. Bases of the pistillidia immersed in the hollow apex of the stem. Antheridia axillary. Amphigastria none.

Cesia crenulata (Gottsche), Carruth. Stems erect or depressed, of a dirty white or brownish colour. Leaves closely imbricated, broadly ovate, bidentate at the apex, crenulate at the margins.

Carrington, Irish Crypt. in Transactions Bot. Soc. Edinb., vol. 7, p. 3, tab. 1, fig. 5 (1863); Gottsche et Rabenhor. Hep. Europ. exsic. n. 478. Jungermannia concinnata, Taylor, in Fl. Hib. 2, p. 59.

Hab. Frequent on the higher mountains in Ireland, and in some few instances descending to sea level. Dr. Carrington refers all the Irish localities for Jung. concinnata to this plant; he considers the true Gymnom. concinnatum, Corda, has not yet been observed in Ireland. After due examination of my own specimens, and some others collected in Ireland, I feel bound to corroborate Dr. Carrington; they are all referrible to G. crenulatum, Gottsche.

Sub-tribe 7. ACROBOLBEÆ.

ACROBOLBUS.

Acrobolbus, Nees, in G. L. et N. Synop. Hepat. p. 5 (1844); Carring. in Brit. Hepat. p. 41 (1874). Gymnanthe, Taylor, in Lehm. Fl. Nov. Pugill. 8, p. 1 (1844); Cooke, Brit. Hepat. p. 15, n. 76, f. 114.

"Involucre terminal, obovate, seated at right angles with the stem, bulbous and rooting on the ventral aspect. Colesule wanting. Calyptra attached to the bulbous base of the receptacle, surrounded by and concrete with the entire portion of the involucre, and bearing around the apex the abortive pistillidia."—Carrington, in British Hepaticæ.

Acrobolbus Wilsoni, Nees. Stems creeping, and mostly parasitical on the stems of larger Hepatics, such as Radula and Frullania. Leaves succubous, roundish or obovate, acutely bifid half-way or more, rarely trilobate, closely placed on the stem, and rather obliquely inserted. Amphigastria wanting. Fructification terminal.

Dilæna, Dumort. Comm. Bot. p. 114 (1822). Diplomitrion, Corda, in Opiz, Naturalient. p. 653 (1829). Diplolæna, Dumort. Syll. Jung. p. 82 (1831). Blyttia, Endl. Gen. Pl. p. 1339 (1840). Steetzia, Lehm. Pl. Preiss. 2, p. 129 (1846). Moerckia, Gottsche, in Rabenhor. Hep. Eur. exsic. n. 295 (1865). Pallavicinia, Carr. Gray's Arr. of Hepat., Trans. Bot. Soc. Edinb. 10, p. 309 (1869).

Involucre monophyllous, laciniated, cup-shaped. Colesule tubular, exserted, frequently cleft at side. Capsule 4-valved, coriaceous, naked. Elaters seminude, deciduous.

Pallavicinia Hibernica (Hook.), B. Gray. Frond dichotomous, ribbed, 1 to 3 inches long, prostrate, forked, margin crisped, entire. Colesule arising from upper surface of the frond, double, exterior very short, laciniated, interior much exserted, ovate-oblong, subplicate.

Jungermannia Hibernica, Hook. Brit. Jung. t. 78, et suppl. t. 4; suppl. to Smith's Engl. Bot. 2, tab. 2750, excl. lower half of plate. Dilæna Hibernica, Dumort. Comm. Bot. p. 114; Hepat. Europ. p. 137. Diplolæna Lyelli, var. γ. Hibernica, Nees, Europ. Leberm. 3, p. 345. Blyttia Lyellii, var. γ. Hibernica, G. L. et N. Synop. Hep. p. 475. Moerckia Hibernica, Gottsche, in Rabenh. Hep. Eur. exsic. n. 295, 334 et 335.

Hab. On damp sandy ground, among the sand-hills near the sea, where water has stood during the winter. Between Malahide and Portrane, Co. Dublin, and at the North Bull. Very sparingly in both places, and seldom fruiting.

Pallavicinia Lyellii (Hook.), B. Gr. Frond oblong-linear, subdichotomous, nerved, crenated or subserrated at margin. Perichætium fimbriated. Colesule cylindrical, double, rising from the nerve on upper side of frond, the outer shortest, notched at the margin, inner slightly toothed at mouth, and torn on one side.

Jungermannia Lyellii, Hook. Brit. Jung. t. 77; Lindenb. Synop. Hepat. p. 96; Ekart, Synop. Jung. p. 68, t. 10, fig. 87. Dilæna Lyellii, Dumort. Comm. Bot. p. 114 (1822); Rev. Jung. p. 25; Hepat. Europ. p. 137. Diplomitrion Lyellii, Corda, in Opiz, Natural. p. 654. Blyttia Lyellii, G. L. et N. Synop. Hep. p. 475; Rabenhor. Hep. Europ. n. 121. Hollia Lyellii, Sullivant, Musci Alleghanienses, p. 66, n. 281. Steetzia Lyellii, Lehman, Plant. Preiss. 2, p. 129; G. L. et N. Synop. Hepat. p. 785.

Hab. Boggy spots among Sphagnum. Rare. Near Bantry, Cork, Miss Hutchins. Lough Bray, Wicklow, Dr. Taylor. Maghanabo glen, near Fermoyle; Castlegregory, and by the lakes between Maghanabo Glen and Connor Hill, Co. Kerry.

PETALOPHYLLUM, Gottsche.

Codonia (*pro parte*), Dumort. Comm. Bot. p. 111 (1822). Diplolæna, sp., Nees, Eur. Leberm. 3, p. 352 (1838). Petalophylli sp. Gottsche, Syn. Hep. p. 471 (1846).

Involucre connate with the colesule. Colesule quadrato-campanulate, mouth infundibuliform, undulate, subdentate. Capsule coriaceous, univalved, ultimately cleft into 4 irregular segments.—Dumortier.

Petalophyllum Ralfsii (Gottsche), Wilson. Frond spreading horizontally, broadly obovate, bluntly forked at apex, lamellated and rayed. Colesule funnel-shaped, broad, and toothed. "Capsule spherical, bursting irregularly."

Jungermannia Ralfsii, Wilson, in suppl. to Engl. Bot. 4, tab. 2874. Diplolæna Lyellii, var. δ. lamellata, Nees, Europ. Leber. 3, p. 345. Petalophyllum Ralfisii, N. G. in Lehm. Pugill. 8, p. 30; G. L. et N. Syn. Hep. p. 472; Cooke, Brit. Jung. p. 22, fig. 167. Codonia Ralfsii, Dumort. Hepat. Europ. p. 16, tab. 1, fig. 2. Petalophyllum lamellatum, Lindberg, Manipulus Musc. secund. p. 390.

Hab. On damp sandy ground near the sea. Malahide sands, and at North Bull sands, both near Dublin. Not hitherto observed elsewhere in Ireland.

BLASIA, Micheli.

Blasia, Mich. Nov. Pl. Gen. p. 14 (1729); Linn. Fl. Suec. ed. 1, p. 933; ed. 2, p. 405 (1745); et Sp. Pl. p. 1605 (1753). Jungermannia, Hook. Brit. Jung. tt. 82–84 (1816).

Frond nerved. Perichætium pitcher-shaped, attached to the apex of the frond. Colesule within the perichætium. Capsule quadrivalved. Elaters geminate. Inflorescence diœcious.

Blasia pusilla (Linn.) Frond oblong, divided at the apex palmately or dichotomously, nerve broad, with scattered dentate scales beneath. Colesule rising from the upper side of the frond near the point.

Blasia pusilla, Linn. Sp. Pl. 1605; Web. et Mohr, Crypt. Germ. p. 437; Hoffm. Germ. 2, p. 22, tab. 3; Dumort. Hepat. Europ. p. 135. Jungermannia Blasia, Hook. Brit. Jung. t. 82–84; Ekart, Synop. tab. 11, fig. 94, et tab. 13, fig. 114; Taylor, in Fl. Hib. p. 56.

Hab. On sandy moist banks by the sides of streams, &c. Fruiting in March at Castle Kelly glen, Dublin, Dr. Taylor. Moist banks near the Wooden Bridge, Wicklow; at the base of Brandon Mountain, Kerry; but not very common anywhere in Ireland.

PELLIA, Raddi.

Jungermannia, Linn. Fl. Suec. 1 ed., p. 399, n. 930 (1745), et Sp. Pl. 1 ed. 2, p. 1135, n. 23 (1753); Hook. Brit. Jung. tab. 47 (1816). Pellia, Raddi in Att. Soc. Modena, 18, p. 49 (1818). Papa, B. Gray, in Gray's Nat. Arr. Brit. Pl. 1, p. 686, n. 12 (1821). Scopulina, Dumort. Comm. Bot. p. 115 (1823).

Perichætium cup-shaped, mouth lacerated. Colesule wanting. Capsule quadrivalved, exserted on a succulent smooth footstalk. Elaters persistent, with two spires.

1. *Pellia epiphylla* (Dill. L.), Raddi. Parœcious. Frond oblong, lobed and sinuate, thick and somewhat fleshy nerved or much thickened in the centre. Fruit from the upper surface of the frond towards the extremity. Perichætium anteriorly formed of the frond, mouth lacerated or dentate. Capsule exserted.

Jungermannia epiphylla, Linn. Sp. Pl. 1 ed., 2, p. 1135; Hook. Brit. Jung. t. 47, figs. 1, 4, 8, 1, 17; Engl. Bot. tab. 771; Fl. Dan. 2, fasc. 6, tab. 359; Lindenb. Synop. Hep. p. 97; Ekart, Synop. Jung. p. 63, t. 7, fig. 52; Taylor, in Fl. Hib. p. 56. Pellia Fabbroniana, Raddi in Att. Soc. Sc. Modena, 18, p. 49; Corda, in Opiz, Natural. p. 654; Dumort. Rev. Jung. p. 27, et Hep. Europ. p. 145; G. L. et N. Synop. Hepat. p. 488; Rabenhor. Hep. Europ. exsic. n. 31, 119, 274, 357.

Hab. On moist clay banks and wet ground. Very abundant in all parts of Ireland.

2. *Pellia calycina* (Nees), Taylor. Diœcious. Frond linear-oblong, dichotomously divided, concave, raised, and sinuate at the edges, midrib well-defined. Fruit rising from the upper surface of the frond over the midrib. Perichætium cup-shaped, subplicate, fringed at the mouth. Calyptra inclosed. Antheridia imbedded in the midrib on the upper surface of the frond.

Jungermannia epiphylla, var. γ. furcigera, Hook. Brit. Jung. t. 47, f. 18, et 2, 3, 9, 10–12. Jungermannia calycina, Taylor, in Fl. Hib. 2, p. 55; Engl. Bot. suppl. t. 2875. Pellia endivifolia, Pluk., Dicks., Lindb. Pellia calycina, Nees, Europ. Leber. 3, p. 386; G. L. et N. Synop. Hepat. p. 490; Rabenhor. Hepat. Europ. exsic. n. 181, 242, 339; Cooke, Brit. Jung. p. 23, fig. 172; Cogn. Hepat. Belg. p. 47.

Hab. Shady moist places, sometimes altogether immersed in water. Dunkerron, Kerry, Dr. Taylor. Torc Cascade and Cromaglown, Dr. Carrington. Altadore glen, and Lough Bray, Wicklow; very large and fine at Glencar, Co. Sligo; Glenballyemon, Antrim.

Sub-tribe 9. Metzgerieæ.

Metzgeria, Raddi.*

Jungermannia, L. Fl. Suec., 1 ed., p. 338, n. 928 (1745), et Sp. Pl. 1 ed., 2, p. 1136, n. 26 (1753); Hook. Brit. Jung., tt. 45, 46 (1816). Metzgeria, Raddi, in Att. Soc. Modena, 18, p. 45 (1818); Lindb. apud Soc. F. Fl. Fenn. (1874); sect. 1, G. L. et N. Synop. Hep., p. 502 (1846). Hervera, B. Gr. in Gray's Nat. Arr. Brit. Pl. 1, p. 685, n. 11 (1821). Fasciola, Dumort. Comm. Bot., p. 114 (1823). Echinogyna, Dumort. Syll. Jung. Eur., p. 83, n. 22 (1831). Echinomitrium, Hüben. Hep. Germ. p. 46, n. 16 (1834).

Fronds ribbed, flat, dichotomous or subpalmately branched. Fruit rising from the lower surface on the midrib. Involucral bract two-lipped, ventricose. Capsules elevated on long stalks, quadrivalved. Elaters persistent to the points of the valves, one-spired. Antheridia from the midrib of under side of frond.

1. *Metzgeria furcata* (Linn.), Dumort. Diœcious. Fronds linear, flat, dichotomously forked, smooth on upper surface, the margin and costa beneath subpilose. Fruit rising from the midrib on the under side. Calyptra setulose.

Jungermannia furcata, Linn. Sp. Pl. 1602; Hook. Brit. Jung., tt. 55 et 56; Lindenb. Synop. Hepat., p. 94; Engl. Bot., t. 1632. Metzgeria glabra, Raddi, Jung. Etr. in Mem. Modena, 18, p. 43, t. 7, fig. 1. Metzgeria furcata, Dumort. Rev. Jung., p. 26; Hepat. Europ., p. 139; G. L. et N. Synop. Hep., p. 302; Rabenhor. Hep. Europ. exsic. 31, 179, 357.

Hab. On trunks of trees chiefly, but also on moist banks and rocks.

Var. δ. *æruginosa.* Frequent on trunks of trees.

2. *Metzgeria pubescens*, Raddi. Frond linear, subdichotomous, glaucous green, nerved, pubescent on both surfaces. Antheridia on the lower surface of the frond, attached to the midrib.

Jungermannia pubescens, Schrank. Prim. Fl. Salisb., p. 231; Hook. Brit. Jung., t. 73; Lindenb. Synop. Hepat., p. 95; Ekart, Synop. Jung., p. 67, t. 3, fig. 19. Metzgeria pubescens, Raddi, Jung. Etrus. Mem. Mod. 18, p. 46; G. L. et N. Synop. Hepat., p. 504; Rabenhor. Hepat. Europ. exsic., n. 84; Dumort. Hepat. Europ., p. 140.

Hab. On moist rocky banks, and in woods. Mountains near Belfast, Mr. Templeton, in Fl. Hib. On limestone rocks between Larne and Glenarm, and at Sillaghbraes, near Larne, Antrim, 1837. Again at same place, M. S. A. Stewart, March, 1876. This rare species has not been found in any of the Irish counties, save Co.

* As a sub-tribe of the Anomogamæ, by Lindberg.

Antrim, up to the present time: good specimens from thence are in the herbarium from the Ordnance Survey, at the College of Science, Dublin.

3. *Metzgeria linearis* (Sw.), Lindb., Monogr. n. 6. Diœcious. Stems robust, much elongated, dichotomous, of equal breadth throughout, their margins much reflexed, nearly meeting so as to make the stems appear half round when dry, in transverse section sub-elliptic, hairs very long, in twos or threes together, spreading widely, and arcuately bent. Fruit (?)

Jungermannia furcata, var. β. elongata, Hook. Brit. Jung. tab. 56, fig. 2; Ekart, Syn. Jung. tab. 1, figs. 1, 2, p. 67. J. furcata, β. maxima, Weber, Spicil. Fl. Goett. p. 160.

Hab. In moist situations on the ground. I collected this remarkable plant in some quantity in a small stream which empties itself into the deep lake at the top of the glen leading up to the highest point of Brandon Mountain, in 1865. The plant was altogether in the water, and the stems were from 4 to 5 inches long. Believing it to be quite distinct from M. furcata, I sent it to some of our best authorities, who thought otherwise. It therefore remained for Dr. Lindberg to establish the species, who also collected it in 1873, at Cromaglaun, &c. He states in his observations on the Hepaticæ collected in Ireland, 1873, that he possesses specimens of the same plant from North America, the islands of Jamaica and Guadeloupe; Sikkim, Himalaya; New Zealand; and from Sutherland shire in Scotland. The Irish specimens have neither male nor female fruit.

4. *Metzgeria conjugata* (Dill.), Lindb., Monogr. n. 7. Autœcious.—"Stems robust, not much elongated, more or less dichotomous, irregularly pinnated or decomposite linear, but narrower in some parts than in others, in transverse section semilunar, margins remote, hairs longish, singly or often in pairs on margin, and divergent."

Bisch. Handb. Bot. Term. tab. 56, fig. 2756; Dill. Hist. Musc. tab. 74, fig. 45; D. et E. Hedw. Theor. Gen. 1 ed., tab. 19, figs. 9, 99 et 100, tab. 20, figs. 101–109; 2 ed., tab. 21, figs. 4, 5, tab. 22, figs. 1–9; Sturm, Deutschl. Fl. 2, fasc. 26, 27, tab. 38; Aust. Hep. Bor.-Am. n. 117 (inflor.); Funck. Crypt. Gew. Ficht. fasc. 21, n. 438; Gottsche et Rabenhor. Hep. Eur. exsic. n. 274–6.

Hab. Glena and Torc Cascade, on the bark of old trees. O'Sullivan's Cascade, Killarney, among Hookeria lætevirens, Dr. Lindberg, 1873. Not being acquainted with this plant, the description and quotations of authorities are after Lindberg, in "Acta Societ. Scientiarum Fennicæ, x." Judging from the figures in Dillenius, it would be readily passed over for a state of Riccardia; so also from the the smaller fig. in Hedwig's Theoria, No. 99, but the magnified fig., No. 100, shows the plant to be a true Metzgeria. In Gottsche and Rabenhor. Hep. Eur. exsic., n. 274, Metzgeria furcata, var. β. nuda, affords a good example of this plant. The paucity of hairs, and more horny substance of the stems, distinguish it from any of the normal states of M. furcata; but the chief distinguishing character seems to be the autœcious inflorescence, which, as Lindberg observes, is remarkable in a genus where all the other species of it are diœcious.*

RICCARDIA, Bennett, Gray.†

Jungermannia, L. Fl. Suec. 1 ed., p. 399, n. 929 (1745), et Sp. Pl., 1 ed., 2, p. 1136, n. 24 et 25 (1741); Hook. Brit. Jung. (1816). Rœmeria, Raddi, in Att. Soc. Modena, 18, p. 46 (1818). Riccardia, B. Gr. in Gray's Nat. Arr. Brit. Pl. 1, p. 683, n. 9, excl. sp. n. 3 (1821); Carruth. in Seem. Journ. Bot. 3, p. 302 (1865). Aneura, Dum. Comm. Bot. p. 115 (1823); Syll. Jung. Eur., p. 85 (1831). Metzgeria, Corda, in Opiz, Beitr., 1, p. 654, n. 12 (1829).

Frond fleshy, pinnatifid or sinuate, partially nerved or without nerve. Fruit rising from the margin of the frond, underneath. Involucre short, cupuliform. Colesule wanting. Calyptra exserted, smooth, fleshy. Capsule quadrivalved. Elaters with a broad single spire, attached to the tips of the valves of the capsule. Antheridia in marginal receptacles.

1. *Riccardia multifida* (Dill., Linn.), Gr. Autœcious. Frond linear, multifid, nerveless, fleshy. Fruit marginal. Calyptra exserted, tuberculated.

Jungermannia multifida, Linn. Sp. Pl. p. 1602; Engl. Bot. t. 186; Hook. Brit. Junger. t. 45, excl. var. β.; Lindenb. Synop. Hepat., p. 98; Aueura multifida, Dumort. Comm. Bot., p. 115; Syll. Jung., p. 85; Hepat. Europ., p. 141; Nees, Europ. Leberm., 3, p. 449; G. L. et N. Synop. Hepat., p. 496; De Notaris, Prim. Hepat. Ital., p. 46; Rabenhor. Hepat. Europ. exsic. n. 463.

Hab. On wet spots, where water has stood during winter, and among wet grass and heaths. Very common in Ireland. Varieties of this variable plant are of frequent occurrence. Variety pinnatifida, Dumort. Syll. Jung. = Aneura pinnatifida, Dumort. Rev. Jung. p. 26; Hepat. Europ., p. 142 (J. sinuata, Dicks. [?]), are found at Killarney; Galtymore, Tipperary; and at Luggielaw: var. submersa, on wet bogs near Mullingar, Westmeath. This

* Although this genus and the following are placed by Lindberg in divisions, according to the principles and characters which mark the respective sections of his arrangement, they are thereby placed among plants they have otherwise little relationship with. I have, therefore, inserted them among those of a more congenial nature, where they have been long and naturally placed. In doing so, I have at the same time indicated the position given them by Dr. Lindberg.

† By Lindberg, as a sub-tribe in the sub-section †, Opisthogamæ.

latter variety grows in the water, in close balls of fronds, three or four inches in diameter. Variety ambrosioides, Nees, Killarney, Dr. Carrington.

2. *Riccardia palmata* (Hedw.), Carruth., Lindb. Diœcious. Stems short, rather crowded, and free at apex, palmately cut, segments linear, and frequently tapering to a point or slightly emarginate. Involucral bracts small. Calyptra small, and densely verrucose.

Jungermannia palmata, Hedw. Theor. Gen. 1 ed., p. 87, tab. 18, figs. 93, 95; et tab. 19, figs. 96–98; Schmid. Icon. Pl. 3, p. 213–216 (excl. synon.); Ekart, Synop. Germ., tab. 13, fig. 115; Fl. Dan. 5, fasc. 15, tab. 898, fig. 3; Sturm, Deutschl. Fl. 2, fasc. 26 et 27, tab. 35. Aneura palmata, Dumort. Comm. Bot. p. 115; Syll. Jung., p. 86, et Hepat. Europ., p. 143; Lindberg, Manipulus Musci. secundus, Helsingfors (1874).

Hab. On the putrid trunks of old trees, at Cromaglaun, Kerry; Altadore Glen, Wicklow. Torc Mountain, and Eagle's Nest, Killarney, Dr. Carrington. Abundant on a small island off Ballynakill Harbour, Co. Galway.

3. *Riccardia pinguis* (Linn.), B. Gr. Diœcious. Fronds procumbent, one or two inches long, fleshy, linear-oblong, simple or slightly lobed, margins sinuate. Fruit rising from under the margin. Calyptra hemispherical, smooth. Capsule brownish and furrowed.

Jungermannia pinguis, Linn. Sp. Plant., p. 1602; Schmidel, Icon. p. 136, tab. 35; Engl. Bot., t. 185; Hook. Brit. Jung., t. 46; Ekart, Synop. Jung., p. 62, tab. 7, fig. 51; Taylor, in Fl. Hib., p. 57. Roemeria pinguis, Raddi, in Mem. Modena, 18, p. 48. Aneura pinguis, Dumort. Comm. Bot., p. 115; Syll. Jung., p. 86, tab. 2; et Hepat. Europ., p. 143; Nees, Europ. Leberm., 3, p. 427; G. L. et N. Synop. Hep., p. 493; Cooke, Brit. Jung., p. 23, fig. 174; Rabenhor. Hep. Europ. exsic. n. 41, 103, 436.

Hab. Damp ravines, sides of rivulets, and among wet heath. Not unfrequent in the Killarney district, Kerry. On wet sand at Malahide, Dublin; and at Lough Bray, Wicklow.

4. *A. latifrons*, Lindberg. "Autoica, rarissime paroica, major, pellucida; caulis longus et latus, dissolutus in ramos latos, cervicorniformes, plus minusve oblongo-cuneatos, obtusissimos et emarginatos, plano-convexos, vix umquam gonidia antice gerentes; cellulæ magnæ, oblongo-rhombeæ, haud incrassatæ; bracteæ perichætiates paucæbus; calyptra magna et minus verrucosa; andrœcium anguste oblongum, fere semper ad latus perichætii affixum." —Lindberg.

Jungermannia multifida, Schmid. Icon. Pl. 3, pp. 213–216, excl. synon. et pp. (1797); Hook. Brit. Jung. p. 19, n. 75, pp. (1816). Aneura palmata, *a* major, Nees, Europ. Leber. 3, p. 459; G. L. et N. Synop. Hepat. p. 498; Gottsche, in Fl. Dan. 16, fasc. 4, p. 21,

n. 2815. A. latifrons, Lindb. apud Soc. pro. F. et Fl. Fenn. (1873), et in Bot. Not. p. 62 (1873). Delin.:—Hook. Brit. Jung., tab. 45, figs. 4, 7 et 12; Ekart, Synop. Germ. tab. 7, fig. 50, 1, 2, et 4; Fl. Dan. 16. fasc. 47, t. 2815, fig. 2.

Hab. On moist turfy banks, and decaying stems of trees. Killarney, Dr. Lindberg.

I have copied closely Dr. Lindberg's description and synonymy (Hepat. in Hiber. Lectæ, p. 513) of this species, which I am not well acquainted with, though Dr. Lindberg pointed it out to me, growing near O'Sullivan's Cascade, Killarney, in 1873. It is the plant figured by Hooker for Jung. multifida, in Brit. Jung. (*pro parte*), and what Dr. Taylor and others, including myself, have long considered that species. Hooker's var. β., which forms part of tab. 45, in Brit. Jung., is described as a species by Dumortier, in Hepat. Europ., viz., Aneura sinuata, p. 142. Although these are conspicuous plants, it is exceedingly difficult to define their limits as species or varieties.

B. CLEISTOCARPÆ.

Tribe 1. SPHÆROCARPEÆ.

SPHÆROCARPUS, Micheli.

Sphærocarpus, Mich. Nov. Pl. Gen. 4, t. 3 (1729); Dumort. Comm. Bot., p. 78 (1822). Targiona sphærocarpus, Dicks. Fasc. 1, p. 8, n. 2 (1785).

Involucre sessile, seated on the frond near its base, pear-shaped and perforated at the apex, without bracts, and one-fruited. Capsule closely invested by the calyptra. Antheridia on separate fronds, in folliculose bodies.

Sphærocarpus terrestris, Sm. Frond roundish, in clusters, horizontally attached to the ground by short radicles, oblong, waved, their disk covered with tufts of the fructification.

Sphærocarpus terrestris, Sm. Engl. Bot. t. 299; Lindenb. Synop. Hep. p. 111; Nees, Eur. Leber. 4, p. 365. Sphærocarpus Michelii, Bellardi, Act. Tur., 5, p. 246; Sullivant's Musci and Hepaticæ of the U. S. p. 84. t. 6. Sphærocarpus lagenarius, Dumort. Comm. Bot. 78.

Hab. On the earth, in fields consisting of strong clay land which are moist in winter. On a wet clay bank at Collin Glen, near Belfast, Mr. David Orr. I have never seen any Irish specimens of this plant, nor have I heard of it having been observed by any other person than Mr. Orr in Ireland.

Section III. Anthocerotaceæ.

Tribe 2. Anthoceroteæ.

Anthoceros, Micheli.

Anthoceros, Mich. Nov. Gen. p. 10, tab. 7 (1729). Corypta, Neck. Elem. Bot. 3, p. 344, n. 1758 (1790). Carpoceros, Dum. Comm. Bot. p. 76 (1823).

Colesule tubular. Capsule filiform, bivalved, with a free central placenta, exserted. Elaters articulated, flexuose, without spores or spores imperfect. Antheridia dorsal, sessile in a cup-shaped involucre.

1. ***Anthoceros punctatus***, Linn. Parœcious. Frond orbicular, radiate, lacerate, with immersed gemmæ in its substance, margins plicate, crenate, papillose on the surface, nerveless. Colesule erect, cylindrical, mouth truncate.

Anthoceros punctatus, Linn. Sp. Pl. 1606; Lindenb. Hepat. Eur., p. 113; Sm. Engl. Bot., t. 1537; Nees, Eur. Leberm. 4, p. 338; G.-L. et N. Synop. Hepat. 583; Rabenhor. Hepat. Eur. exsic. n. 64, 462, 484.

Hab. Wet places, by the sides of streams, and on ditch banks. Glendoon, Co. Antrim; Kelly's Glen, Co. Dublin. Sugar Loaf Mountain, Co. of Wicklow, Dr. E. Perceval Wright; but not common in the northern or eastern counties of Ireland. Frequent in the counties of Kerry and Cork.

This remarkable genus among the Hepaticæ is easily recognised when found in fruit, but when not in a fruiting state, the species may readily be passed over for states of Pellia. From most of the Marchantiaceæ the fronds may be distinguished with the aid of a lens, by the absence of true pores on their surface.

2. ***Anthoceros lævis*** (Dill), L. Diœcious, (Lindb.) Frond deep green, smooth on surface, nerveless, subradiate. Colesule broad, scarious.

Anthoceros lævis, Linn. Sp. Pl. 1606; Lindenb. Hepat. Eur. p. 112; Nees, Europ. Leber, 4, p. 329; G. L. et N. Synop. Hepat. p. 586; Rabenhor. Hep. Eur. exsic. n. 64, 462, 484.

Hab. On clay banks, &c. On a wet clay bank, by the roadside leading from Dingle to Ventry, left-hand side of road, about a mile and a-half from Ventry. This species was collected in considerable abundance by Dr. Lindberg and myself, in July, 1873, when it was in fine fruit. I am not aware of it having been observed elsewhere in Ireland up to the present time.

LIST OF WORKS, PAPERS, ETC., RELATING TO THE HEPATICÆ OF IRELAND.

THOMAS TAYLOR, M. D. :—

"In Flora Hibernica. Part 2. Hepaticæ (1836)." Eighty-two species are described and enumerated.

"Descriptions of Jungermannia ulicina (Taylor) and Jungermannia Lyoni (Taylor)." Transactions of the Edinburgh Botanical Society. Vol. 1, p. 115 (1841). Adds J. Lyoni (Taylor) to the Irish list.

"On two new species of Jungermannia, and another new to Britain." Transactions of the Edinburgh Botanical Society. Vol. 1, p. 179 (1843–4). Adds J. punctata, Taylor.

"On four new species of British Jungermannia." Transactions of the Edinburgh Botanical Society. Vol. 2, p. 43 (1843). Adds Jungermannia riparia, Taylor; J. reclusa, Taylor; J. fragifolia, Taylor; J. germana, Taylor.

"Contributions to British Jungermannia." Transactions of the Edinburgh Botanical Society. Vol. 2, p. 115 (1844). Adds Jungermannia nimbosa, Taylor; J. curta, Martius; J. Thuja, Dickson; J. rivularis, Nees; J. aquilegia, Taylor.

D. MOORE, Ph. D. :—

"Ordnance Survey Collections of Counties of Derry and Antrim." Vol. 1. Mosses and Hepaticæ, exsicc. (1834–8). Fifty-five species.

"Contributions to the British and Irish Musci and Hepaticæ." Proceedings of Dublin University Zoological and Botanical Association. Vol. 2, p. 80 (1863). [Read February 20th, 1861]. Adds Sarcoscyphus Funckii (1837); Scapania subalpina, var. β. undulifolia; Aneura palmata; Petalophyllum Ralfsii, Wilson; and a new habitat for J. cuneifolia.

"Dublin Natural History Society's Proceedings." Vol. 5, p. 89 (1866). Adds Scapania undulata, var. *A.* major, Nees; and some new habitats.

THOMAS POWER, M. D. :—

"Contributions towards the Fauna and Flora of Cork. Part 2. Botany (1844)." Fifty species of Hepaticæ are enumerated.

B. CARRINGTON, M. D. :—

"Gleanings among the Irish Cryptogams." Transactions of the Edinburgh Botanical Society. Vol. 7, p. 379 (1863). Adds Jungermannia obovata, Nees; and, gleaned from other sources, Preissia commutata, Nees; Fossombronia angulosa, Raddi; Scapania compacta, Lindenb.; S. irrigua, Nees; J. nana, Nees; J. bicrenata, Lindb.; Gymnanthe Wilsoni, Taylor; Madotheca lævigata, Dumort.; and Madotheca rivularis, Nees.

S. O. Lindberg :—

"Hepaticæ in Hibernia mense Julii, 1873, lectæ." Acta Societatis Scientiarum Fennicæ, x. (1874). Adds Riccia sorocarpa, Bischoff; Lejeunea patens, Lindb.; Lejeunea Moorei, Lindb.; Porella pinnata, Dill.; Metzgeria linearis, Sw.; Metzgeria conjugata, Lindb.; Cephalozia multiflora (Dill.), Huds.; Cephalozia elachista, Jack.; Kantia arguta, Dill.; Riccardia latifrons (Schmid.), Lindb.; Nardia sphacelata, Gies.; Scalia Hookeri (Lyell), Gray; Anthoceros lævis (Dill.), L.

The species added in the present Report are Ricciella fluitans, Al. Braun, Hook.; Ricciocarpus natans, Corda; Cephalozia Francisii, Hook.; Pedinophyllum pyrenaicum, Spruce; Scapania uliginosa, Dumort.; Scapania æquiloba, Dumort. (vera); Jungermannia Hornschuchiana, Nees; Jungermannia capitata, Hook.; Nardia revoluta, Nees; Sphærocarpus terrestris, Sm.; Lejeunea flava, Swartz.

G. M. Cotter, in M. F. Cusack's "History of the City and County of Cork" (1875), enumerates twenty-nine Hepaticæ not noticed in Dr. Power's list of 1844.

ADDITIONS AND CORRECTIONS.

Lejeunea flava, Swartz. Stem branched, creeping. Leaves subimbricated, oblong-ovate, entire, rounded at apex, lobule somewhat convolute. Amphigastria ovate-cordate, much smaller than the leaves, acutely bifid, divisions ovate-lanceolate. Fruit lateral at base of branchlets. Colesule exserted, pentagonal.—Gottsche, Ic. Lej. vii.

Junger. flava, Swartz, Prodr. Fl. Ind.-Occ. p. 144; Fl. Ind.-Occ. iii. p. 1859; Schwæger, Prodr. p. 16; Web. Prodr. p. 29; Spreng. S. V. 4, 1, p. 223, n. 74; Spruce, in Trimen's Journal of Botany, new series, vol. v. 1876, p. 198.

Hab. Killarney, J. T. Mackay.

Dr. Spruce assures us that a fine patch of this plant, gathered at Killarney by the late Mr. Mackay, is in Sir William Hooker's herbarium. Dr. Lindberg considers that this species is closely allied to his new species, L. Moorei. Referring to the latter, he states: "Very probably this new and very distinct species is to be very carefully compared with L. flava, Swartz; and I have really felt doubt whether the two are different from each other; but as I have not seen the former (L. flava), I am unable to decide" (Lindb. in "Acta Societatis Scientiarum Fennicæ," x. p. 487). I am myself in a similar position to that of Dr. Lindberg, not having seen plants of L. flava, and therefore cannot offer an opinion at present.

LIV.—A REVISION OF THE SPECIES OF ABIES. By WILLIAM RAMSAY M'NAB, M. D., Edinburgh, Professor of Botany, Royal College of Science for Ireland. (With Plates 46, 47, 48 and 49.)

[Read June 26, 1876].

LAST year I presented to the Royal Irish Academy a paper (*antea*, p. 209), in which the anatomy of the leaves of the section Tsuga of the genus Pinus was described, and in the present paper I propose to continue the investigation of the anatomical structure of the leaves of the same great genus. The sections to which I shall now direct attention are Abies of Endlicher and Parlatore, and Pseudotsuga of Carrière and Bertrand, the former including a considerable number of species of which the common European silver fir may be taken as the type. Much confusion has been caused by Linnæus in 1753 falling into an error as to the application of the names Picea and Abies—an error which was corrected by Duroi in 1771; but in this paper I shall not follow Parlatore in calling the common silver fir (generally known by the name of Abies pectinata of De Candolle) Pinus (Abies) Abies of Duroi; but shall adopt the more commonly used A. pectinata.

Dr. C. E. Bertrand* enumerates and briefly describes the anatomical characters of twenty-two species of Abies. All Bertrand's forms, with a single exception, I believe I have been able to examine; and while we agree in many most important points, still in others I find considerable discrepancies in our results. Perhaps this may result from an examination of but few examples of each species, and this I have tried to avoid by examining as many specimens as I could obtain, both living and dried. A very large number of specimens have been examined, and many thousands of sections cut—the greater part of my spare time for twelve months past having been devoted to the work.

Great confusion exists in the nomenclature of this section; the synonymy is very complex, and the cultivated forms frequently do not agree with the species described by Botanical authors. It has, therefore, been difficult in many cases to discover what the true plant of the original describer was, but I have been very fortunate in obtaining a great deal of information regarding the cultivated species introduced into Britain within the last twenty-five years from my father, who has cultivated most of the species with the greatest success, and whose accurate and extensive knowledge of this genus is well known. All the forms introduced by Jeffrey have been raised from seed in the Royal Botanic Garden at Edinburgh, and I have thus been able to obtain, from the Museum, and from the Edinburgh Botanic Garden, authentic specimens of the different forms for examination. To Dr. Hooker and Professor Oliver I am very deeply indebted for permission

* Anatomie Comparée des Tiges et des Feuilles chez les Gnétacées et les Conifères. Paris, 1874.

to examine authentic specimens from the Kew Herbarium, many difficulties having been removed by their kind assistance; while Professor Perceval Wright also helped me greatly by his kindness in enabling me to examine the authentic specimens in the Herbarium of Trinity College, Dublin. To many other friends—Dr. Moore, of Glasnevin; Mr. Fowler, of Castle Kennedy; Mr. Syme, Elvaston Nurseries; Messrs. Waterer, Low, and Veitch—my best thanks are also due.

Parlatore* enumerates and describes eighteen species and two varieties in his section Abies, but he seems in some instances to have mixed up two or more anatomically distinct forms under one name. Each form has been carefully described, and a figure of the section of the leaf given, so that this paper may, to a certain extent, be useful in identifying the cultivated species in our gardens and nurseries.

The species of Abies are generally separated into two groups by the bracts of the cones, which are either long or short. Bertrand separates two groups by the position of the résin-canals. In the present paper I have adopted a geographical arrangement, as I find that the forms most related anatomically are most connected geographically, the outlying forms being generally the most distinct. A great zone of species stretches from North America, by Japan and the Himalayas, to Asia Minor and Southern Europe.

The section Abies of Pinus is distinguished by having the leaves inserted singly into the stem, by their not being placed on cushions, and by the double fibro-vascular bundle. The second section mentioned in this paper is Pseudotsuga, which differs in having a single fibro-vascular bundle.

I. Abies, Endl., Parlatore. Genus Abies, Link. Abies, Bertrand.

1. *Pinus* (*Abies*) *bracteata*, Don, Trans. Linn. Soc. xvii. 443; Parlatore, D. C. Prod., vol. xvi., pars 2, p. 419, No. 88. *Pinus venusta*, Dougl. *Abies venusta*, Koch, Dendrologie, vol. ii. part 2, p. 210.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows; occasionally a few directed upwards. Leaf rigid, linear, twisted above the base, which is slightly narrowed towards the orbicular insertion, widest above the twisted part, then gradually tapering, contracting suddenly near the sharp-pointed apex; upper surface bright green with no stomata, beneath with a band of stomata on each side of the midrib, there being from 10 to 12 rows of stomata in each band. Leaves from 1½ to 2 inches in length, and about $\frac{1}{10}$ of an inch wide. Buds covered with pale yellow scales, which are not resinous.

Transverse section of leaf.—Leaf flattened, 3½ times broader than thick, sides rounded, upper surface gently curved inwards, below with

* De Candolle, Prodromus, vol. xvi., sect. 2, pp. 419, *et seq.*

a prominent midrib. Hypoderma well developed, a continuous band of thickened cells running underneath the epidermis of the upper surface, from the external margin of the one resin-canal to the external margin of the other. At the rounded margins of the leaf the hypoderma consists of two rows of cells. The hypoderma is also developed under the epidermis covering the prominent midrib below, the layer of cells being double in the middle. The resin-canals are placed one at each side of the leaf, close to the under side, and separated from the epidermis by a single layer of cells. The pallisade parenchyma is well developed on the upper side, and below there is parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed close together, and having a few thick liber-like cells above and in the middle. The whole is surrounded by a sheath.

The figure (Plate 46, fig. 1) is drawn from a specimen supplied to me by Mr. Syme, Elvaston Nurseries, Borrowash, Derby.

Bertrand* gives the following characters for A. bracteata:—Glands touching the inferior epidermis; no stomata on upper surface of leaf, more than 10 rows of stomata in each band; no pseudo-liber cells in parenchyma of leaf; zone of hypoderm continuous; leaf mucronate.—In the different specimens examined by me the same characters were found.

Gordon† describes this species, and directs attention to the buds, while Koch‡ gives a description of it under the name of Pinus (Abies) venusta. According to this author the name venusta, Douglas (1836), has the priority by one year of that of bracteata, D. Don (1837). It has also been described and figured by Mr. Andrew Murray, in the Transactions of the Botanical Society of Edinburgh, vol. vi., p. 211, with plates. Koch states that the young shoots are hairy, while Parlatore says: "Ramuli glabri:" both states occur among the specimens examined by me.

P. (Abies) bracteata is one of the most distinct species of the whole section. Five different specimens have been examined by me—three from their natural habitats, the others cultivated.

I am indebted to my valued correspondent, Mr. Syme, of Elvaston Nurseries, Borrowash, Derby, for a fine cultivated specimen for examination, a section of the leaf of this plant being the one figured. The other cultivated specimen examined was from a very small plant in Glasnevin Garden, kindly given to me by Dr. Moore, and in it the hypoderm was not so well developed, there being 2 or 3 cells omitted in 3 or 4 places, but it agreed in all other characters.

I am indebted to Dr. Hooker, C.B., P.R.S., and to Prof. Oliver, F.R.S., for permission to examine two specimens in Kew Herbarium. One is a specimen collected by D. Douglas in "America boreali-occi-

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* *Op. cit.*, p. 89. † The Pinetum (1858), p. 145.
‡ Dendrologie, vol. ii., part 2, p. 210.

dentalis;" the other was marked "119, Picea bracteata, W. Lobb, California." These specimens of Douglas and Lobb have in every respect the same anatomical characters as the specimen from Elvaston Nurseries, figured in the paper.

There is a specimen with cones in the Museum, Royal Botanic Garden, Edinburgh, presented by Mr. Andrew Murray in 1859. The leaves of this specimen do not differ anatomically from those already described.

2. *Pinus* (*Abies*) *religiosa*, Humb., Bonpl. and Kunth, Nov. Gen. et Sp. 2, p. 5; Parlatore, D. C. Prod. vol. xvi., pars 2, p. 420, No. 91.

Shoots hairy or smooth. Leaves inserted singly, and not very closely, all round the stem, but bent so as to form two lateral rows. Upper side of shoot with leaves directed outwards at a small angle. Leaf linear, straight or curved, slightly twisted above the base, contracting at apex into a point, upper surface deep green with no stomata, below with a band of stomata on each side of the midrib, there being from 8 to 10 rows in each band. Leaves from 1 to 1½ inch in length, and about $\frac{1}{16}$ inch wide. Buds pale-coloured, and very resinous.

Transverse section of leaf.—Leaf flattened, nearly three times broader than thick, sides rounded, upper surface with a central longitudinal furrow, below with a slightly prominent midrib. Hypoderma conspicuous, forming a continuous, or only very slightly interrupted, band, extending from the resin-canal of one side underneath the epidermis of the upper surface to the resin-canal of the other side: below the epidermis of the midrib a series of hypoderm cells also exists. The resin-canals are two in number, placed close to the epidermis of the under side of the leaf, and rather near the margin. The pallisade parenchyma is well developed on whole upper part of leaf; below, the parenchyma, with intercellular spaces communicating with the stomata, is well seen.

Fibro-vascular bundle double, surrounded by a well-developed sheath; the parts of the bundle are not widely separated, and a few thick liber-like cells are placed superiorly.

The figure (Plate 46, fig. 2) is drawn from a specimen kindly supplied to me by Mr. Fowler, gardener, Castle Kennedy, N. B.

Pinus (Abies) religiosa is very closely related to P. bracteata, and Bertrand says that the two do not differ anatomically. The shape of the leaf in section is, however, different, and the thick hypoderm cells are larger and more interrupted than in P. bracteata. I have seen two specimens from Castle Kennedy, one figured above, the other in the Museum, Royal Botanic Garden, Edinburgh. It has a cone, ripened in 1867, about 4 inches long by 2 wide, with projecting bracts. The specimen from Glasnevin was in an unhealthy condition when examined, and has the hypoderm less developed than in the Castle Kennedy specimens. In Kew Herbarium is a specimen, marked "Abies religiosa, Guatemala, Skinner;" and on the label also, "Abies hirtella. Differt ab Ab. religiosa foliis obtusissimis emarginatis, nec acutissimis." This seems to me only to differ from religiosa in having the hypoderm cells more scattered, and it resembles in every way the young leaves on the plant of religiosa from Glasnevin Garden. Some of the leaves on the Castle Kennedy specimens are rather obtuse, so that there may be a little variation in this interesting form.

I place religiosa next bracteata, which it resembles much in its leaves, but it differs in its cone.

3. *Pinus* (*Abies*) *amabilis*, Douglas, Bot. Mag. Comp. 2, p. 93 (not Parlatore). *Abies grandis*, A. Murray, Syn. Var. Conif., p. 18 (not Douglas). *A. grandis*, Lambert (?). *Picea lasiocarpa*, Balf. in Jeff. seeds, p. 1, t. 4, f. 1 (not Hook.). *Abies spectabilis*, Herpin de Fremont, Bertrand, Anat. Gnét. et Conif. p. 91 (not Don).

Shoots densely covered with small dark hairs. Leaves inserted singly all round the stem, and placed very close together, the leaves on the under side of the stem and the lateral ones forming two lateral rows spreading outwards, those on the upper side of the branch twisted round so as to bring the upper surfaces of the leaves superiorly: these upper leaves all point to the apex of the shoot, nearly parallel to its long axis, and give the branches a very peculiar appearance. Leaf linear, more or less twisted at the base, which narrows towards the orbicular insertion, width nearly uniform, apex rounded and emarginate, upper surface very bright green with no stomata, beneath with a band of stomata on each side of the midrib, there being from 8 to 10 rows of small stomata in each band. Leaves 1 to $1\frac{1}{4}$ inch long by about $\frac{1}{16}$ inch wide. Buds covered with brown scales, and resinous.

Transverse section of leaf.—Leaf flattened, three times broader than thick, sides rounded, upper surface with a faint longitudinal furrow, the midrib not prominent. Hypoderma well developed, forming a continuous, or nearly continuous, layer running from the resin-canal of one side, under the upper epidermis, to the resin-canal of the other; the hypoderm is also developed in the middle line below. The resin-canals are placed, one at each side of the leaf, close to the inferior epidermis, but sometimes having a layer of hypoderm separating the canal from the epidermis. The pallisade parenchyma is well developed on the upper side, and below is parenchyma, with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the whole surrounded by a well-marked sheath.

The figure (Plate 46, fig. 3) is drawn from a specimen supplied to me by my father, from the Royal Botanic Garden, Edinburgh.

The peculiar appearance of the foliage of this plant is well shown in Mr. Murray's figure (Syn. Var. Conif. p. 19, fig. 20), an appearance which is considered characteristic of amabilis of Douglas. It seems probable that this is not the plant meant by Douglas to be called amabilis, but that the form he really wished to bear this name is now known as Pseudotsuga magnifica.

I have examined in all eleven specimens of this plant. It has been sent to me from the Royal Botanic Garden in Edinburgh as the true amabilis of Douglas, grafts and layers from Douglas' plants being there cultivated. I have also received it from Mr. Syme, of Elvaston Nurseries, as the true amabilis of Douglas, as well as from Mr. Waterer, of Knap Hill Nursery. A plant of it was noticed last September by Dr. Moore, of Glasnevin, growing near Ambleside, in the Lake District. I have also examined five native specimens—three in Kew Herbarium, from the Oregon Boundary Commission: one collected in St. Juan Island, by Dr. Lyell, in 1858; another, near Lake Chilukweyak, B. C., Cascade Mountains, 49° N. L., Dr. Lyell, 1859; and the third, Cascade Mountains to Fort Colville, about 49° N. L., Dr. Lyell, July, 1860. A section of the leaf of one of these is figured (Plate 46, fig. 3, a.)

In the Museum at the Royal Botanic Garden, Edinburgh, there is a cone, about 4 inches long, with a few leaves, marked "Pinus lasiocarpa, 409. California, Mr. Jeffrey, 1853." In the Herbarium is a specimen of the same, marked "Picea sp., No. 409. Mountains east of the Falls of Fraser's River, Sept. 27, 1851, Jeffrey." This No. 409, Jeff., is A. lasiocarpa of Balfour and Oregon Committee, as shown by the figure given by Mr. A. Murray, Syn. Var. Conif. p. 25, fig. 34. From an examination of both the cone and leaves, I have no difficulty in identifying this plant as being lasiocarpa of Balfour, grandis of Murray, and probably of Lambert, and amabilis of Douglas, as represented in our gardens. No plants of this, Balfour's lasiocarpa, seem to have grown from Jeffrey's seeds.

From the great development of hypoderm, I place this species next to bracteata and religiosa. The cone is unlike that of the two species, and has large bracts, which do not project beyond the scales.

4. *Pinus* (*Abies*) *grandis*, Douglas, Bot. Mag. Comp. 2, p. 147; Parlatore, D. C. Prod. xvi. p. 427, No. 104 (excl. of syn.). *Abies amabilis*, Murray, Syn. Var. Conif. p. 20; Koch, Dendrologie, vol. ii. pt. 2, p. 211. *Abies Gordoniana*, Carr. Conif. ed. 2, p. 298; Bertrand, Anat. Comp. Gnét. et Conif. p. 91.

Shoots smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows; occasionally a few are directed upwards. Leaf linear, twisted at the base, which is slightly narrowed towards the orbicular insertion; width of leaf nearly uniform, with a rounded emarginate apex, upper surface bright green, with no stomata, or very rarely with a small cluster of 3 or 4 near the apex, beneath with a band of stomata on each side of the midrib, there being from 7 to 8 rows of stomata in each band. Leaves from 1 to 1¼ inch long, and about $\frac{1}{12}$ inch wide. Buds covered with resinous brown-coloured scales.

Transverse section of leaf.—Leaf flattened, about three times broader than thick, sides rounded, upper surface with a faint longitudinal furrow, the midrib not prominent. Hypoderma consisting of a few scattered cells under the upper epidermis, one or two at the sides of the resin-canals, and a few inferiorly in the middle line. The resin-canals are placed, one at each side of the leaf, close to the epidermis of the under surface. The pallisade parenchyma is well developed on the upper side, and below is parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed close together, the whole surrounded by a well-marked sheath.

The figure (Plate 46, fig. 4) is drawn from a specimen supplied to me by my father, while Pl. 46, fig. 4, a, is from a specimen sent under the name of A. lasiocarpa.

Much confusion exists in regard to this species, a confusion which seems to have begun at the very beginning, and to have been made still worse by the Oregon Association distributing several plants under one name. I have been able to examine many specimens, and shall briefly give the result of my investigations.

Specimens of grandis have reached me from three different sources, all purporting to be grandis of Douglas. The first comes from the Royal Botanic Garden, Edinburgh, where it has been long cultivated, and my father sends it to me with the note that it is a layer from one of Douglas's original plants. The same plant is cultivated in the Botanic Garden, Glasnevin, and is marked as the true grandis of Douglas. The third specimen comes from Mr. Barron, of Elvaston Nurseries, and was sent to me by Dr. Masters. All these have the same foliage, and the same peculiar anatomical structure of the leaf, and the peculiar scattered hypoderm cells. Assuming, then, that this plant is probably the true grandis of Douglas, an examination of recently introduced specimens will show a great deal of confusion.

In the Museum and Herbarium of the Royal Botanic Garden, Edinburgh, Jeffrey's original specimens are preserved, and I have been enabled to examine them carefully, through the kindness of Professor Balfour, F.R.S. In the Museum there is a cone in a net, and lying beside the cone is a shoot with leaves, bearing a label in Jeffrey's handwriting. The cone is 5 inches long, by 2½ inches wide, and shows the short pointed bract. There seems little doubt that the cone belongs to the shoot, as shown by the examination of other specimens. On the label is the following—

Picea. No. 393.

Along the banks of Fraser's River, from the Falls to the Ocean.

Sept. 30, 1851.

There is another cone in the collection, marked "P. lasiocarpa? Jeffrey, 393." The cone is in pieces, and seems to have measured about 4 inches by 2. No leaves are attached to this specimen. The scale and bract is the same as that figured by Mr. Murray, Syn. Var. Conif. p. 25, figure 32.

In the Herbarium there are two specimens, one with part of an immature cone, the other with the whole of a small one, also immature. Both are marked "No. 393, Jeffrey, Picea, sp." One bears a long printed label; the other, with the entire cone, is marked by my father, "P. Lowii."

In Kew Herbarium there is a specimen from the Oregon Association, No. 393, with the printed label, and erroneous date, 1852. Jeffrey's No. 393 is, undoubtedly, the same as grandis, Douglas; but it is extensively cultivated as Picea lasiocarpa. My father has sent me two specimens of it for examination, one marked "Picea lasiocarpa. Introduced by Jeffrey, and described by Mr. Murray," meaning that it is the lasiocarpa of the Oregon Committee. (See Trans. Ed. Bot. Soc., vol. xi. p. 326). Mr. Murray (Syn. Var. Conif. p. 24) is quite correct in stating that Jeffrey's No. 393 is Douglas's grandis, and not lasiocarpa. A specimen of lasiocarpa, received from Mr. Barron of Elvaston, through Dr. Masters, is also grandis; hence Mr. Barron's conclusion that lasiocarpa only equals grandis.

Lasiocarpa of the Oregon Committee, Jeffrey, No. 409, is a different plant, already noticed as amabilis.

I have examined sixteen specimens—ten cultivated, and six native—of Picea grandis, Douglas, and have received it under three different names:

A. grandis, Hort. Edin., Hort. Glasnevin., Hort. Barron.
P. lasiocarpa, Hort. Edin.
P. amabilis, Hort. Glasnevin.

There is a specimen in Kew Herbarium from Dr. Lyell, marked "Abies grandis, Dgl. ?," from the Columbia River, lat. 46°–49° N.

A specimen in the Edinburgh Museum, marked "grandis," from Mr. Andrew Murray, is Lowiana.

5. *Pinus* (*Abies*) *Lowiana*, Gordon, Supp. to Pinetum, p. 53; A. Murray, Syn. of Var. Conif. p. 27. *A. Parsonsiana*, Hort. *A. lasiocarpa*, Hort.

Shoots hairy. Leaves inserted singly all round the stem, but bent so as to form two lateral rows; occasionally a few are directed upwards. Leaf linear, twisted at the base, some only slightly, others twisted through half a turn, width nearly uniform, apex rounded and emarginate, upper surface bright green, with 6 or 7 (or fewer,) rows of stomata in a central band, beneath with a band of stomata on each side of the midrib, there being from 9 to 10 rows in each band. Leaves 1 to 2 inches in length, and about $\frac{1}{12}$ inch wide. Buds covered with resinous brownish scales.

Transverse section of leaf.—Leaf flattened, about three times as broad as thick, sides rounded, upper surface with a faint longitudinal furrow, below without a prominent midrib. Hypoderma well developed at the margins of the leaf; scattered cells under the upper epidermis, and a few cells below, under the fibro-vascular bundle. The resin-canals are placed, one at each side of the leaf, close to the under side. The pallisade tissue is interrupted above by the presence of stomata.

The fibro-vascular bundle is double, the parts not placed very close together, the whole surrounded by a well-marked sheath.

The figure (Plate 46, fig. 5) is drawn from a specimen grown in the Royal Botanic Garden, Edinburgh, from seed sent by Jeffrey.

I have examined nine specimens of this plant, six of them being cultivated, and three native specimens. In the Museum, Royal Botanic Garden, Edinburgh, is a cone with a shoot having leaves tied to it, which is marked "Picea Lowii (P. grandis). Oregon, Mr. Jeffrey, 1854." The cone is 4 inches long by 2½ inches wide. The scale and seed are both large, the bract being very short. The part that is free from the scale is broader than long; the margin is toothed, with a sharp-pointed apex, indeed, agreeing very well with Mr. Gordon's description. The number in Jeffrey's list is not given, and I failed to find more than the one specimen of Jeffrey's. I have little doubt that the seeds were mixed with those of Jeffrey's 393 and 409, and the three things all sent out as P. lasiocarpa, Oregon Committee; hence the name it receives in certain gardens. Lowiana was sent home by Mr. William Murray, as there is a shoot of it, without a cone, in the Museum, in the Royal Botanic Garden, Edinburgh, marked "Picea grandis. California, W. Murray, Esq. Presented by A. Murray, Esq., 1860." In Kew Herbarium is a specimen marked, "No. 3. California, — Low, Esq., Clapton." It is also cultivated as Parsonsiana, and I have received it as such from Edinburgh, and from Mr. Barron, Elvaston Nurseries, per Dr. Masters.

6. *Pinus* (*Abies*) *concolor*, Engelm. Herb.; Parlatore, D. C. Prod., xvi., pars 2, p. 426, No. 103. *Picea concolor*, Gordon, Pinetum, p. 155.

Leaves about 1½ inch long, and $\frac{1}{12}$ inch broad, linear, curved, twisted at base, rather obtuse at apex, stomata on both sides—about 15 rows on the upper side, and two bands below, each with about 8 or 10 rows of stomata.

Transverse section of leaf.—Leaf about 2½ times as broad as thick, rather tetragonous in form although much flattened, sides rounded, upper surface convex with no furrow, below with a rather prominent midrib. Hypoderma developed at the sides of the leaf, and below the epidermis of the midrib, occasionally a few scattered cells in other parts of the leaf between the rows of stomata. The resin-canals are placed, one at each side of the leaf, close to the lower epidermis. The pallisade tissue is not developed, owing to the presence of stomata on both sides of the leaf.

Fibro-vascular bundle double, the two parts rather widely separated, and with a well-marked sheath surrounding the whole.

The figure (Plate 46, fig. 6) is drawn from the specimen in Kew Herbarium from Fendler, "Pl. Novo-Mexicano," No. 828, 1847.

This species is very distinct anatomically, and as far as I know is not yet in cultivation, not having received it from any of our gardens and nurseries.

M. Bertrand (*loc. cit.* p. 89) gives Abies concolor as a synonym of Abies grandis, Lindl., but gives the characters of concolor for the species.

7. *Pinus lasiocarpa*, Hooker, Fl. Bor. Amer. ii., p. 163, (not Balfour.) *Abies bifolia*, A. Murray, Proc. of Royal Hort. Soc. London, iii., p. 320. *P. amabilis*, Parlatore, D. C. Prod., vol. xvi., p. 426, No. 102 (in part). ? *Picea amabilis*, Newberry.

Leaves of two forms, those on ordinary branches from ½ to 1¼ inch long, and grooved on the upper side, those on the cone-bearing shoots shorter, and without the groove. Stomata on both sides of the leaf, above with many rows especially near the apex, below with two bands on each side of the rather prominent midrib, there being from 6 to 8 rows in each band. Leaves either pointed, or blunt, or slightly emarginate, from $\frac{1}{16}$ to $\frac{1}{12}$ inch wide.

Transverse section of leaf.—Leaf (ordinary. branch) flattened, about three times as broad as thick, sides rounded, upper surface with a central longitudinal furrow, below with a prominent midrib. Leaf (cone-bearing branch) tetragonal, more than half as thick as wide, with no furrow. Hypoderma developed at edges of leaf below epidermis of midrib, and generally superiorly. Resin-canals in the parenchyma of the leaf, and remote from the inferior epidermis.

Fibro-vascular bundle double, and surrounded by a well-marked sheath.

I have examined nine dried specimens, all of which I refer to this species. The first is a specimen in Kew Herbarium: the leaves were sent to me by Prof. Oliver, and labelled "P. lasiocarpa, Hook. (sp. typica). Coll. Douglas." This specimen first showed me that P. lasiocarpa, Hooker, was not P. lasiocarpa of Balfour, or of our gardens. A transverse section of the leaf is figured in Plate 46, fig. 7. My valued correspondent, Mr. Syme, of Elvaston Nurseries, sent me leaves of P. bifolia, A. Murray, got from M. Roezl. These on examination proved to be the same as P. lasiocarpa, Hooker. The two forms of leaves were sent by Mr. Syme—both the grooved and quadrangular forms. One of the leaves is figured in section (Plate 47, fig. 8). Mr. Syme adds on the label of the specimen sent to me the note: "M. Roezl informs me that it is not very handsome." Young plants sent by Mr. Syme were also examined, but they did not present the distinctive features of the species. Five specimens from Kew Herbarium were then examined, collected by Dr. Lyell in 1860 and 1861, and in the collection of the Oregon Boundary Commission. These specimens were collected in the Cascade Mountains, Galton range of Rocky Mountains, and along the Columbia River, through 10° of latitude, viz., from 39°N. to 49°N.; and on the Galton range, at an elevation of 7000 feet. These are, in fact, the types of Mr. Murray's "bifolia," and one of the specimens is marked "Ab. amabilis, Douglas, fid. Parlatore." An unnamed specimen from Douglas also exists in Kew Herbarium (Plate 46, fig. 7,, a.)

When examining the specimens in the Royal Botanic Garden, Edinburgh, I found a specimen marked "Picea magnifica robusta. Oregon, Mr. Jeffrey, 1853." Two cones and a few leaves were preserved in the Museum, and I was able at once to refer the specimen to P. bifolia of Murray, or P. lasiocarpa, Hooker.

The section of the leaf from the cone-bearing branch in Kew Herbarium with the label, "Colville, Indian name 'Marcilp.' Hab. East side of Cascade Mountains, latitude 49°N. Not uncommon up to 6000 feet above the sea. Aug., 1860," is figured (Plate 47 fig. 9).

After the most careful examination of these specimens I am compelled to come to the conclusion that P. lasiocarpa of Hooker is a good species which has been confounded with other forms by subsequent botanists. I further conclude that bifolia of Murray is a synonym of P. lasiocarpa, Hooker. From an examination of the cones of grandis, magnifica, and bifolia, I find that it is very difficult to separate them by external characters, all being hairy or "lasiocarpous;" and as magnifica and bifolia are mixed in the Museum in Edinburgh, it shows that thoroughly competent botanists may confound them. By an examination of the bract, the two can be readily separated: the bract of magnifica is large, while that of bifolia is very small. If we bear in mind that amabilis, Douglas, and lasiocarpa, Hooker, were described within a comparatively short time of each other, I feel constrained to consider that the two things are and were distinct. Further, when we consider M. Roezl's note, mentioned above, that it is not a handsome plant, I think we could hardly agree with Parlatore in calling it amabilis, Douglas. The scale, but not the bract, of amabilis, Douglas, is figured in Loudon's "Arboretum," and he mentions that the bract is very short and pointed; in fact, the cone he figured was bifolia, Murray. I feel quite confident that the plant Douglas meant to call amabilis is magnifica of Murray, and not bifolia of Murray, but in the absence of authentic specimens, I think we should retain the name amabilis for the plant long cultivated under that name, and retain the name of lasiocarpa, Hook., for this species, while we use A. Murray's name, magnifica, for the species which Douglas undoubtedly meant should be called amabilis.

The scale and bract of Jeffrey's specimen in the Museum of the Royal Botanic Garden, Edinburgh, were examined. The cones, two in number, are 6 inches long, by about 2¼ inches wide. Another one in the same collection, 7½ inches long, and 2 inches wide, marked "P. Pinsapo, from Ronda in Spain," belongs to the same species, viz., lasiocarpa, Hook.

This species is probably A. amabilis (Forbes), Bertrand, which Bertrand says does not differ anatomically from A. Fraseri.

8. *Pinus* (*Abies*) *Fraseri*, Pursh, Fl. Bor. Amer. 2, p. 639; Parlatore, D. C. Prod., xvi., pars 2, p. 419, No. 90.

Shoots hairy, the surface broken and uneven from the presence of resin-canals. Leaves inserted singly all round the stem, bent at base so as to be irregularly two-rowed, a few of the leaves directed upwards. Leaf linear, bent at the base or straight, short, leathery, apex obtuse or emarginate, upper surface deep green with several rows of stomata in the central furrow, beneath with a band of stomata on each side of the midrib, there being from 8 to 9 rows of stomata in each band. Leaves about $\frac{1}{2}$ inch in length, and about $\frac{1}{12}$ inch wide. Buds large, covered with yellowish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, three times broader than thick, sides rounded, upper surface with a well-marked central groove, below with a distinct but not very prominent midrib. Hypoderma moderately developed, irregularly scattered below superior epidermis and forming a very much interrupted layer, the layer continuous at the rounded margins, one, rarely two, cells thick; a layer of hypoderm below at the midrib forming a single layer of cells with a few scattered here and there forming a double row. The resin-canals are placed in the parenchyma of the leaf, and separated from the inferior epidermis by many layers of chlorophyll-bearing cells. The pallisade parenchyma is developed at each side of the groove above, but is defective where the stomata are present.

Fibro-vascular bundle double, surrounded by a well-marked sheath.

The figure (Plate 47, fig. 10) is drawn from a specimen supplied to me by Mr. Fowler, gardener, Castle Kennedy, N. B.

I have examined four specimens of this species, only one of which is from a cultivated specimen. There is a cone $2\frac{1}{4}$ inches long by 1 broad, in the Museum, Royal Botanic Garden, Edinburgh, ripened at Castle Kennedy, but it has no leaves. The other three specimens I have examined are from Kew Herbarium. The first is from the summit of the Hoosack Mountains, Massachusetts—Pinus Fraseri, Pursh. The second is marked "P. balsamea. Canada, P. Fraseri;" the third, "Pinus americanus, Newfoundland. Herb. Forsyth." About the two last I am rather doubtful, as I find it very difficult to separate Fraseri and balsamea by anatomical characters only.

9. *Pinus* (*Abies*) *balsamea*, Linn. Sp. Pl. p. 1421; Parlatore, D. C. Prod. vol. xvi. pars 2, p. 423, No. 95.

Shoots hairy, the surface broken and uneven from the presence of resin-canals. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, a few being directed upwards. Leaf linear, twisted at the base, which is narrowed towards the orbicular insertion, apex emarginate, upper surface dark green, with two or more rows of stomata in the middle line near the apex, beneath with a band of stomata on each side of the midrib, there being about ten rows of stomata in each band. Leaves from $\frac{1}{2}$ to $\frac{3}{4}$ inch long, and about

$\frac{1}{12}$ inch wide. Buds covered with brownish scales, which are very resinous.

Transverse section of leaf.—Leaf flattened, about three times broader than thick, sides rounded, upper surface with a faint longitudinal furrow, below with a slightly prominent midrib. Hypoderma wanting; very rarely there are one or two cells at the rounded margin, and one or two below the fibro-vascular bundles. The resin-canals are placed in the parenchyma of the leaf, and although sometimes running very near the lower surface, are always separated from the epidermis by chlorophyll-bearing cells. The pallisade parenchyma is well developed on the upper side, as the stomata rarely extend down the leaf for any distance, although occasionally a single row may run for about two-thirds of the length; below, the parenchyma has intercellular spaces communicating with the stomata.

The fibro-vascular bundle is double, the whole surrounded by a well-marked sheath.

The figure (Plate 47, fig. 11) is drawn from a specimen grown in the Royal Botanic Garden, Edinburgh.

I have examined five specimens of this species: one specimen grown in the Royal Botanic Garden, Edinburgh; one from Mr. Syme, Elvaston Nurseries; two specimens are from Kew Herbarium—one marked "P. balsamea. Canada, Mr. Perceval;" the other, "P. balsamea, L. Gonan;" the fifth specimen is from the Museum, Royal Botanic Garden, Edinburgh. The leaves examined are from the base of a cluster of cones, and are very interesting, as having a considerable quantity of hypoderm developed. Like P. lasiocarpa, this species is bifolious, and the leaves resemble those of P. Fraseri. Indeed, I find it very difficult to separate the two forms, viz., Fraseri and balsamea, by characters derived from the structure of the leaf.

10. *Pinus* (*Abies*) *sibirica*, Turcz., Cat. Baekal, No. 1067; Parlatore, D. C. Prod. vol. xvi. pars 2, p. 425, No. 101. *Abies sibirica*, Ledeb. Fl. Alt. 4, p. 202. *Picea Pichta*, Loud. Arbor. Brit. 4, 2338. *Abies Pichta*, Forbes, Pin. Wob. 109, t. 37.

Shoots hairy or smooth. Leaves inserted singly and close together all round the shoot, those on the under side bent to form two lateral rows, those on the upper side directed with their points upwards and forwards towards apex of the shoot. Leaf linear, twisted above the base, which is slightly narrowed towards the orbicular insertion, width nearly uniform throughout the entire length, apex rounded or slightly truncate, upper surface dark green, with no stomata, beneath with a band of stomata on each side of the midrib, there being from 4 to 5 rows in each band. Leaves from $\frac{1}{2}$ to $1\frac{1}{2}$ inch long, and about $\frac{1}{12}$ inch wide. Buds brownish, and very resinous.

Transverse section of leaf.—Leaf flattened, about three times as broad as thick, sides rounded, upper surface with a slight longitudinal furrow, below with a very faintly prominent midrib. Hypoderma entirely absent. The resin-canals are placed in the parenchyma of the leaf, sometimes, however, rather low, but always separated by chlorophyll-bearing cells from the lower epidermis. Pallisade tissue well developed under superior epidermis, the parenchyma with intercellular spaces communicating with the stomata, well developed below.

Fibro-vascular bundle double, with one or two thickened cells above and below, the whole surrounded by a well-marked sheath.

The figure (Plate 47, fig. 12) is drawn from a plant cultivated in Glasnevin Garden, and kindly supplied to me by Dr. Moore.

This species is cultivated in the Botanic Garden, Glasnevin, and in the Royal Botanic Garden, Edinburgh, under the name of Pichta. I have also received it from Mr. Syme, of Elvaston Nurseries, correctly named sibirica. In Mr. Syme's specimen a single thick hypoderm cell was noticed in one leaf under the epidermis covering the midrib below.

11. (*Pinus Abies*) *Veitchii*. *Picea Veitchii*, Lindley, Gard. Chron., Jan. 1861. *Abies Veitchii*, A. Murray, Sketch of Conif. of Japan, p. 39. *Pinus selenolepis*, Parlatore, D. C. Prod. xvi., p. 427, No. 105.

Shoots and arrangement of leaves not observed. Leaf flat, linear, grooved on upper side, apex obtuse and emarginate, above glaucous green, with no stomata, below with two bands of stomata on each side of the midrib, there being from 6 to 7 rows of stomata in each band. Leaf from ½ to 1 inch long, and about $\frac{1}{16}$ inch broad.

Transverse section of leaf.—Leaf flattened, about three times as broad as thick, sides rounded, upper surface with a longitudinal furrow, below with a slightly prominent midrib. Hypoderma only slightly developed, a few cells being placed above and below, touching the epidermis in the middle line. No hypoderm, or rarely a single thickened cell, at the rounded margin of the leaf. The resin-canals are placed in the middle of the parenchyma. The pallisade parenchyma is well developed above, and the parenchyma with intercellular spaces below.

The fibro-vascular bundle is double, the tissue between the bundles and the well-developed sheath being thickened.

The figure (Plate 47, fig. 13) is drawn from a dried specimen in Kew Herbarium.

This species does not seem to be in cultivation, and the only specimen known to me is that in Kew Herbarium. The single specimen has two labels, viz. :—"No. 946. Abies microsperma. From Fusi Yami. 2/63. Yokohama;" and "813. Picea Veitchii, Ldl. Oldham legit."

It is undoubtedly the Abies Veitchii of description, and is perfectly distinct from Abies Veitchii of gardens.

12. *Pinus* (*Abies*) *firma*, Antoine, Conif. 70, tab. 27, *bis*. *Abies firma*, Siebold and Zuccarini, Flora Japon. ii., 15, tab. 107 (not Parlatore). *Abies homolepis* (?), Sieb. and Zucc., Flora Jap., ii., 17, t. 108. *Abies brachyphylla*, Maxim. Pl. exsicc. *Pinus brachyphylla*, Parl., D. C. Prod. xvi., 2., p. 424.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows. Leaf linear, twisted above the base, which is slightly narrowed towards the orbicular insertion, width tolerably uniform, or slightly greater towards the apex, which is rounded and emarginate, upper surface green, occasionally with a few stomata in a patch near the apex, but generally without stomata, beneath with a band of stomata on each side of the prominent midrib, there being from 10 to 11 rows of stomata in each band. Leaf from $\frac{1}{2}$ to $1\frac{1}{4}$ inch in length, and about $\frac{1}{10}$ inch wide. Buds?

Transverse section of leaf.—Leaf flattened, three times as broad as thick, sides rounded, upper surface convex, with a well-marked central furrow, below with a prominent midrib. Hypoderma well developed, forming a continuous layer extending all round the leaf, except where the two bands of stomata occur on the lower surface on each side of the midrib. The resin-canals are placed, one at each side of the leaf, in the parenchyma of the leaf, and separated from the lower epidermis by many chlorophyll-bearing cells. The pallisade parenchyma is well developed on the upper side, and below is the parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the two parts placed rather close together, and having a number of very thick liber-like cells below. The whole is surrounded by a well-marked sheath.

The figure (Plate 47, fig. 14) is drawn from a specimen from Kew Herbarium, and is not yet in cultivation as far as I can learn.

I have only seen three specimens of this species, all of which are in the Kew Herbarium, and I am indebted to Dr. Hooker and Prof. Oliver for leave to examine them. The first is marked "812. Abies firma, S. & Z. Nagasaki, Japan, 1862. Oldham." The second, from which the figure is drawn, has the label, "Ex herb. Hort. Bot. Petropol. Maximiowicz, iter secundum. Abies firma, S. & Z. Japonia, Nippon, 1864." The third specimen is that with the label, "Ex herb. Hort. Bot. Petropol. Maximiowicz, iter secundum. Abies brachyphylla, Maxim. Japonia, Yokohama, 1862."

Very much confusion exists regarding this and the next species (P. bifida). All the examples cultivated under the name of firma that I have yet seen are bifida. As the specimen marked "brachyphylla" in Kew Herbarium is authentic, it will be seen that the species described by Maximiowicz, and adopted by Parlatore, must sink as a synonym of firma, Sieb. and Zucc., if the plant here noticed be Siebold and Zuccarini's species. Bertrand correctly gives the characters of Abies firma as here defined. Mr. Andrew Murray (Conifers of Japan, p. 53) mixes up firma and bifida; but his figures 98 and 99 would certainly apply very well to firma, and fig. 108 to bifida.

Koch (Dendrologie, vol. 2, pt. 2, page 227) adopts Mr. Murray's view of the identity of firma and bifida, but adopts the name of Abies Momi, Sieb., for the united forms. As the species are markedly distinct, anatomically, I have no hesitation in separating them; and at the same time, as I cannot find the slightest difference to exist between firma and brachyphylla, I have as little hesitation in uniting them.

13. *Pinus* (*Abies*) *bifida*, Ant. Conif. p. 79, t. 31, f. 2. *Abies bifida*, Sieb. and Zucc., Flor. Japon., 2, p. 18, t. 109. *Abies firma*, A. Murray, Conif. of Japan, p. 53.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, rarely a few pointing downwards or upwards. Leaf linear, twisted above the base which is slightly narrowed towards the orbicular insertion, then gradually tapering, with a bifid apex, the two portions being very acute; upper surface bright green, with no stomata, beneath with a band of stomata on each side of the midrib, there being from 10 to 12 rows in each band. Leaves varying in length from ½ to 1½ inch, about $\frac{1}{10}$ inch wide at widest part. Buds covered with brownish scales, which are resinous.

Transverse section of leaf.—Leaf flattened, 3½ times as broad as thick, sides with a rather acute lateral margin; upper surface convex, with a central longitudinal furrow, midrib not prominent below. Hypoderma well developed, forming a slightly interrupted row of cells running from the margin of the resin-canal of one side to the margin of the resin-canal of the other side; the hypoderm is also developed under the epidermis covering the midrib. The resin-canals are placed, one at each side of the leaf, generally quite close to the epidermis of the under side of the leaf, but in the same leaf the resin-canal may become small, and be separated from the epidermis by one or two chlorophyll-bearing cells. The ground parenchyma of the leaf is distinguished by the occurrence of numerous large thickened prosenchymatous cells or idioblasts, which are unbranched, and have their long axes parallel to the long axis of the leaf. These idioblasts are a special peculiarity of this species, and are called pseudo-liber fibres by Bertrand. The pallisade tissue is well developed on the upper side, and below is the parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed close together, with several thickened liber-like cells, sometimes above and always below the bundles, the whole surrounded by a sheath.

The figure (Plate 47, fig. 15) is drawn from a specimen supplied to me by Messrs. Veitch & Sons, Chelsea, under the name of Abies firma.

I have examined five specimens of this, all presenting the marked characteristics of the species. There is a specimen in Kew Herbarium, marked A. bifida, Sieb. and Zucc., which is the same as this, but I have not examined it microscopically. It is cultivated in the Royal Botanic Garden, Edinburgh, under the correct name of P. bifida, and there is another plant, differing only in the smaller size of the leaves, which my father sent as P. sp., Japan. It is the species cultivated in gardens and nurseries as Abies firma, and under that name I have received it from Messrs. Veitch, and Mr. Fowler of Castle Kennedy. Mr. Fowler sends two forms—one marked by him as a late variety; anatomically they are the same, except that the late variety shows great irregularity in the size and position of the resin-canals, being normal, in the lower half of the leaf, but in the parenchyma, near the apex.

This species can at once be separated from firma by the presence of the remarkable idioblasts as well as by the margin and apex of the leaf.

Abies homolepis, Sieb. and Zucc., I have not seen, but from Bertrand's description of the leaf I would consider it a synonym of A. firma.

Pinus holophylla, Parlatore; Abies holophylla, Maxim., is also unknown to me except by Parlatore's description in D. C. Prod., vol. xvi., pt. 2, p. 424. It is from Mandschuria.

14. *Pinus* (*Abies*) *Harryana*, n. sp. *Abies Veitchii*, Hort, *not* descr.

Shoots smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, a few projecting upwards and downwards. Leaf linear, twisted above the base, widest above the twist, getting gradually narrower, then suddenly contracting near the apex into a sharp, simple, or bifid point; upper surface bright green, without stomata except in a few rare cases where a small cluster of three or four occur near the apex, beneath with a band of stomata on each side of the midrib, there being from 7 to 8 rows of stomata in each band. Leaves from $\frac{1}{2}$ to $1\frac{1}{4}$ inch long, and about $\frac{1}{12}$ inch wide. Buds covered with pale brown very resinous scales.

Transverse section of leaf.—Leaf flattened, about $3\frac{1}{2}$ times as broad as thick, sides rounded, upper surface with a longitudinal furrow, below with a slightly prominent midrib. Hypoderma well developed, forming a slightly interrupted band, extending from the anterior side of the resin-canal of the one side, under the epidermis of the upper side of the leaf, to the side of the resin-canal of the other side; the hypoderma is also developed under the epidermis of the midrib. The resin-canals are placed, one at each side of the leaf, close to the lower epidermis. The pallisade tissue is well developed on the upper side, and below is parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed very close together, and having a large number of bast fibres below; the fibro-vascular bundles and the bast fibres surrounded by a well-marked sheath.

The figure (Plate 47, fig. 16) is drawn from a specimen kindly supplied to me by Messrs. Veitch and Sons, Royal Exotic Nursery, Chelsea, London.

This sharp-leaved form can be at once distinguished from the obtuse emarginate-leaved A. Veitchii. Then their anatomical characters are remarkably distinct. Veitchii in the Kew Herbarium has the resin-canals in the parenchyma of the leaf, and possesses very little hypoderm. The same characters are given by Bertrand for Veitchii, so that there can be no doubt that we have both had the same plant under examination. The Veitchii from Veitch's Nursery; Royal Botanic Garden, Edinburgh; Mr. Syme, Elvaston Nurseries; and the Lawson Nursery Co. (Limited), Edinburgh, is quite distinct, having the resin-canals, close to the lower epidermis, and the hypoderm well developed. In the absence of sufficient materials for description, as the cone remains unknown, I would provisionally name it Pinus Harryana, after Mr. Harry Veitch, the head of the firm of Veitch & Sons.

The leaves of this species rather closely resemble in general form and appearance those of Pinus (Pseudotsuga) Fortunei, Murray, and it seems not improbable that it may have been confounded with that plant under the name of Jezoensis. It is a Japanese species, but is not A. Jezoensis, Sieb. et Zucc., to judge from the figure.

15. *Pinus* (*Abies*) *Pindrow*, Royle, Himal. p. 354, t. 86; Parlatore, D. C. Prod. vol. xvi. pars 2, p. 424, No. 99. *Abies Pindrow*, Spach, Hist. Nat. d. Veg. Phan. xi. p. 423. *Picea Pindrow*, Loud., Arb. Brit. iv., 2346.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, a few directed upwards and downwards. Leaf long and linear, twisted above the base, narrowed towards the orbicular insertion, width uniform, the apex bifid, with two narrow sharp points, upper surface deep green with no stomata, beneath with a more or less conspicuous band of stomata on each side of the midrib, there being from 7 to 8 rows in each band. Leaves from 1 to 2½ inches long, and about $\frac{1}{12}$ inch wide. Buds resinous, covered with brownish scales.

Transverse section of leaf.—Leaf flattened, four times as broad as thick, sides rounded, upper surface with a slightly marked longitudinal furrow, midrib not prominent below. Hypoderma well developed, forming a continuous, or very nearly continuous, band from the resin-canal of one side, under the epidermis of the upper surface, to the resin-canal of the other side; the hypoderma is also developed below the fibro-vascular bundles. The resin-canals are placed, one at each side of the leaf, close to the epidermis of the under side. The pallisade parenchyma is well developed on the upper side, and below is the parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts rather widely separated, a few thick cells developed both above and below; the whole surrounded by a well-marked sheath.

The figure (Plate 47, fig. 17) is drawn from a specimen kindly supplied to me by Dr. Moore, and cultivated in Glasnevin Garden.

Mr. Syme, of Elvaston Nurseries, has directed my attention to the fact that this species has the shoots either hairy or smooth, both in young and old plants.

Bertrand (*loc. cit.* p. 89) says that Pindrow has "Très-peu d'hypoderma;" this I have only found in exceedingly young leaves, all others examined by me having abundance of hypoderm. He seems to have confused the species from the Himalayas, because he says, p. 91, "A. Webbiana, Lind., ne diffère pas anatomiquement de l'A. Pindrow, Spach," in which statement I cannot concur.

16. *Pinus* (*Abies*) *Webbiana*, Wall, MSS.; Parlatore, D. C. Prod. xvi. pars 2, p. 425, No. 100. *Pinus spectabilis*, Lamb., Pin. ed. 2, vol. 2, p. 3, t. 2. *Abies Webbiana*, Spach. *Picea Webbiana*, Loudon, Arb. Brit. iv. p. 2346.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but directed chiefly towards the two sides, those on the upper side with their points directed towards the apex of the shoot, and nearly parallel to its axis. Leaf long, linear, twisted more or less according to its position on the shoot, base narrowed towards the orbicular insertion. Breadth of leaf uniform through most of its length, slightly contracted near the bifid apex, the two portions being small and very sharp, or slightly rounded; upper surface dark green, with no stomata, beneath with a band of stomata on each side of the midrib, there being from 8 to 10 rows in each band. Leaves from 1 to 2½ inches long, and about $\frac{1}{16}$ inch wide. Buds brownish and resinous.

Transverse section of leaf.—Leaf about four times as broad as thick, sides with a well-marked lateral line, upper surface convex, with a well-marked longitudinal furrow, below with a slightly prominent midrib. Hypoderma rather well developed, forming an interrupted band running from the resin-canal of one side, under epidermis of upper surface, to the resin-canal of the other side; the hypoderm is also developed under the epidermis of the slightly prominent midrib. The resin-canals are placed, one at each side of the leaf, close to the epidermis of the under surface. The pallisade tissue is well developed on the upper side, and below is the parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, with thick cells above and below, the whole surrounded by a well-marked sheath.

The figure (Plate 48, fig. 18) is drawn from a specimen cultivated at Glasnevin Garden, and kindly supplied to me by Dr. Moore.

This species, like A. Pindrow, has the shoots either glabrous or hairy when young or old, and I am again indebted to Mr. Syme, of Elvaston, for specimens showing this. In young plants the hypoderm is only very feebly developed, but the form of the section of the leaf at once separates it from Pindrow.

Mr. Syme sent a specimen under the name of Picea Webbiana ovata, which I cannot separate anatomically from the type.

There is a specimen in the Museum, Royal Botanic Garden, Edinburgh, of cone and leaves from Castle Martyr, Co. Cork. The cone is about 6 inches long by 2¼ inches broad. On examining the leaves attached to the shoot, they are found to have the same anatomical characters as those already described. In the same Museum are two other cones without leaves—one from Castle Martyr measuring 7 inches by 2¼ inches, and the other from Holkam Hall, which only measures 5½ inches in length by 2½ inches in breadth.

17. *Pinus* (*Abies*), sp. nov. (?)

I have met with two specimens of a pine closely related to Pindrow and Webbiana, which on further investigation may turn out to be new. The first specimen was noticed while examining the specimens in the Herbarium of Trinity College, Dublin. It was marked, "Abies Webbiana, Himalaya occid., 9,000 to 12,000, Hook. fil. et Thomson." The leaves are 1½ to 2 inches in length, and only very slightly notched at the apex. The second specimen was met with in the Museum, Royal Botanic Garden, Edinburgh. It was a fine cone-bearing shoot, with leaves, and had been grown at Castle Kennedy, in Scotland. The cone measures 2½ inches by 2, and the leaves are long and narrow, 2 inches long in most cases, from $\frac{1}{18}$ to $\frac{1}{10}$ inch wide, and only slightly notched at the apex.

Transverse section of leaf.—Leaf flattened, about four times as broad as thick, sides rounded, upper surface with a slightly-marked longitudinal furrow, below with a scarcely prominent midrib. Hypoderma well developed, forming a continuous (Castle Kennedy specimen) or slightly interrupted (Himalayan specimen) band running all round the leaf, except where the stomata are developed in a band on each side of the midrib. The resin-canals are in the parenchyma of the leaf, and separated from the lower epidermis by several chlorophyll-bearing cells. The pallisade parenchyma is well developed on the upper side, there being no stomata on the upper epidermis, and below is the parenchyma with intercellular spaces communicating with the stomata, of which there are about 10 rows in each of the bands.

Fibro-vascular bundle double, with thickened cells above and below, the whole surrounded by a well-marked sheath.

The figure (Pl. 48, fig. 19) is drawn from the Himalayan specimen, which is smaller, and possesses less hypoderm than the specimen from Castle Kennedy.

The cone is small, in this resembling Pindrow, but as it was unbroken the bracts could not be described.

Although I have examined eleven different cultivated specimens of Webbiana and Pindrow, I have only met with this one new form from Castle Kennedy, so that it must be very rare in our gardens and nurseries.

I abstain from giving this a name, as the synonymy of the group is obscure, and already several different names have been given to supposed species.

18. *Pinus* (*Abies*) *pectinata*, Lam. Fl. Franç., ii., 202 (1778). *Pinus Abies*, Duroi, Obs. Bot., p. 39; Parlatore, D.C. Prod. vol. xvi. p. 420, No. 92 (in part). *Pinus Picea*, Linn. Sp. Plant. ii., 1001 (1753). *Abies Picea*, Koch, Dendrologie, vol. ii., pt. ii., p. 217.

Shoots hairy. Leaves inserted singly all round the stem, the lower ones bent to form two lateral rows, those on the upper side more or less spreading, and bent at the base so as to bring the superior surface upwards, the inferior surface being next the axis. Leaf linear, more or less twisted above the base according to the position on the stem, apex rounded or emarginate, upper surface shining dark green with no stomata, below with a band of stomata on each side of the slightly prominent midrib, there being 7 or 8 rows of stomata in each band. Leaves about $\frac{3}{4}$ to 1 inch in length, and $\frac{1}{16}$ inch wide. Buds covered with slightly resinous brown scales.

Transverse section of leaf.—Leaf flattened, about $2\frac{1}{2}$ times broader than thick, sides rounded, the leaf becoming markedly thinner towards the margins, upper surface with a longitudinal furrow, below with a slightly prominent midrib. Hypoderma well developed, a slightly interrupted row of cells running from near the resin-canal of one side to near the resin-canal of the other side. The hypoderm is also developed below the epidermis of the midrib. Resin-canals placed, one on each side of the leaf in the parenchyma, and separated from the lower epidermis by layers of chlorophyll-bearing cells. Pallisade tissue well developed on upper side, the parenchyma below with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed rather close together, the whole surrounded by a sheath.

The figure (Plate 48, fig. 20) is drawn from a specimen from Glasnevin Garden, kindly given to me by Dr. Moore.

Bertrand (*op. cit.* p. 90) places A. pectinata in the group with the resin-canals touching the lower epidermis, and adds that Nordmanniana appears to be little different from A. pectinata. All the specimens of A. pectinata that I have examined have the resin-canals in the parenchyma of the leaf, so that I conclude that the A. pectinata examined by Bertrand was a variety of A. Nordmanniana.

All the specimens examined by me have the resin-canals in the parenchyma of the leaf, and have the hypoderm well developed; the quantity of hypoderm varies, and is least developed in the plant growing in the Botanic Garden, Glasnevin. This very interesting tree was raised from seed by Dr. Moore, the seed having been received from the Himalayas, and transmitted to Dr. Moore by the East India Company. The leaves of this plant are wider, and have a sharper or less rounded margin than the typical form; and this, taken along with the feebler development of the hypoderm, might warrant the separation of the plant under the name of variety Mooreana. (Pl. 48, fig. 21).

The leaves from a cone-bearing shoot in the Museum, Royal Botanic Garden, Edinburgh, were examined, and found to have a more tetragonal form, there being no longitudinal furrow visible. The leaves, therefore, seem to me inclined to be of two shapes, thus resembling bifolia, Murray (lasiocarpa, Hooker).

Specimens from Edinburgh, Glasnevin, and Cirencester, have been examined, but no dried specimens from native habitats.

19. *Pinus* (*Abies*) *Nordmanniana*, Stev., Bull. de la Soc. d. Nat. de Mosc., xi. 45 (1838). *Pinus Abies*, Duroi; Parlatore, D.C. Prod. vol. xvi., p. 421, No. 92 (in part).

Shoots hairy or smooth. Leaves inserted singly all round the stem, those below bent so as to form two lateral rows, those above directed more or less upwards, and twisted at the base so as to bring the upper surface of the leaf superiorly. Leaf linear, more or less twisted at base, apex emarginate, upper surface yellowish green, with no stomata, beneath with a band of stomata on each side of the slightly prominent midrib, there being from 8 to 9 rows of stomata in each band. Leaves from 1 inch to 1¼ inch in length, and about $\frac{1}{16}$ inch wide. Buds covered with reddish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, three times broader than thick, sides rounded, upper surface only faintly grooved, below with a scarcely prominent midrib. Hypoderma well developed, forming a slightly interrupted band, running from the resin-canal of one side, under the upper epidermis, to the resin-canal of the other side. The hypoderm is also developed under the epidermis covering the midrib. The resin-canals are placed at each side of the leaf, close to the under surface, and separated from the epidermis by a single layer of cells. The pallisade tissue is well developed above, and below is the parenchyma with intercellular spaces.

Fibro-vascular bundle double; parts placed close together, and having a well-marked sheath.

The figure (Plate 48, fig. 22) is drawn from a specimen from Glasnevin, given to me by Dr. Moore.

The difference in the position of the resin-canals at once separates Nordmanniana from pectinata; the shape of the leaf and the arrangement of the hypoderma being similar. Plants from Edinburgh, Glasnevin, and Cirencester have been examined, but none from native habitats. The leaves on the cone-bearing shoot differ from those on the ordinary branches only in having the midrib slightly more prominent.

20. *Pinus* (*Abies*) *cilicica*, Kotschy, in Osterr. Bot. Wochenblatt, iii., 409 (1853); Parlatore, D. C. Prod. xvi., p. 422, No. 93.

Shoots hairy or smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows; several point upwards, and very few are directed downwards. Leaves linear, twisted above the base, especially in those leaves on the upper part of the shoot which are turned so as to have the superior surface upwards, apex obtuse and emarginate, upper surface green, with no stomata, beneath with a band of stomata on each side of the midrib, there being from 7 to 8 rows of stomata in each band. Leaves from 1 to 1¼ inch in length, and about $\frac{1}{12}$ inch wide. Buds covered with yellowish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, about 3½ times as broad as thick, sides rounded, upper surface with a very slightly marked longitudinal furrow, below without a prominent midrib. Hypoderma conspicuous, forming a single, more or less interrupted layer, running from the resin-canal of one side, under the epidermis of the upper side of the leaf, to the resin-canal of the other side; there is also a small row beneath the epidermis in the middle line below. The resin-canals are placed, one on each side of the leaf, near the margin and close to the epidermis of the under side of the leaf. The pallisade tissue is well developed on the upper side of the leaf, while below is the parenchyma, with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the whole surrounded by a well-marked sheath.

The figure (Plate 48, fig. 23) is drawn from an original specimen of Kotschy's, No. 370, in the Herbarium of Trinity College, Dublin, kindly given to me for examination by Professor Perceval Wright, M.D.

I have only examined three specimens of this pine—one from Mr. Syme, of Elvaston Nurseries; one from Glasnevin; and the third from Trinity College, Dublin, Herbarium, collected by Kotschy in Syria: "in regionibus Daniæ, supra Eden, alt. 5000. Die 28 Jul. 1855." Anatomically it is the same as P. Nordmanniana; but I have not seen the cones, and so cannot give any definite opinion as to its distinctness. Bertrand* says of this species: "Pas d'hypoderm sous l'épiderme supérieur." In all my specimens the hypoderm is well developed, so that probably Bertrand has made some mistake.

There is a cone in the Museum, Royal Botanic Garden, Edinburgh, measuring 6 inches by 2 inches, and marked "Abies cilicica. Crimea, P. Lawson & Sons, 1856." It has no leaves, but after most careful examination I have no hesitation in referring the cone to Abies bifolia, Murray,—the P. lasiocarpa, Hooker.

21. *Pinus* (*Abies*) *cephalonica.* Endl., Cat. Hort. Acad. Vindob. i., 218. *Pinus* (*Abies*) *β. cephalonica,* Parl., D. C. Prod. xvi., 2, p. 422, No. 92. *Abies cephalonica,* Link., Linnæa, 15, p. 529. *Picea cephalonica,* Loudon, Encyc. Trees, 1039.

Shoots smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, many pointing upwards, very few projecting downwards; the leaves at the sides of the shoot are twisted at the base; those above and below are not, or only very

* Anat. Comp. des Gnét. et Conif. p. 89.

slightly, twisted. Leaf linear, narrow at base, widest above base, contracting gradually towards the apex, and then suddenly narrowing with a sharp point; upper surface dark shining green, generally with no stomata, but occasionally with a partial row near the apex of the leaf in the middle line, below with a band of stomata on each side of the midrib, there being from 6 to 7 rows in each band. Leaves about 1 inch in length, and about $\frac{1}{12}$ inch wide. Buds covered with yellowish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, about three times broader than thick, sides rounded, upper surface nearly flat or gently curved inwards, below with a slightly prominent midrib. Hypoderma well developed, forming a continuous layer from the resin-canal of one side, under the upper epidermis, to the resin-canal of the other side; at the margins the hypoderm is greatly developed, being generally three cells thick, a double layer of hypoderm below the double fibro-vascular bundle. The resin-canals are placed at each side of the leaf, close to the epidermis of the under side. The pallisade parenchyma is well developed on the upper side, while below is the parenchyma with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the whole surrounded by a well-marked sheath.

The figure (Plate 48, fig. 24) is drawn from a specimen grown in Glasnevin Garden, and kindly given to me by Dr. Moore.

A plant growing in the Botanic Garden, at the Agricultural College, Cirencester, had an incomplete row of stomata on the upper side of the leaf.

Specimens from Glasnevin, Edinburgh, and Cirencester have been examined. One from the Museum, Royal Botanic Garden, Edinburgh, has cones; and the leaves from the cone-bearing shoots do not differ from those on the ordinary branches, except that the leaf is, at the apex, slightly bevelled off from behind, and there are a few stomata near the apex.

The forms described as Abies Reginæ Ameliæ, Heldr., and Abies Apollinis, Link., have been examined. According to Mr. Andrew Murray (Lawson's "Pinetum," part v.), Reginæ Ameliæ is a variety of Abies Apollinis, which he makes a species distinct from A. cephalonica. Mr. Murray says of Reginæ Ameliæ, "foliis crassis, sub-acuminatis;" but I cannot observe any difference between the leaves of this form and P. cephalonica except that the hypoderma is less developed. The leaves of a cone-bearing shoot of cephalonica are like those figured by Mr. Murray (Lawson, "Pinetum," part v., fig. 1) for Apollinis, while the leaves of the plant cultivated in the Royal Botanic Garden, Edinburgh, differ only in having the margin less rounded, and having a slightly developed longitudinal furrow above.

Mr. Murray (Pinet. Brit., part iii.) gives figures of P. Panachaica, Heldr., and reduces that species to P. cephalonica. From an examination of Mr. Murray's figures, and of recent specimens, I have no hesitation in reducing A. Reginæ Ameliæ, Heldr., and A. Panachaica, Heldr., to cephalonica, while Apollinis may rank as a variety, bridging over the space between P. cephalonica and P. Nordmanniana. A section of the leaf of A. Apollinis is figured (Plate 48, fig. 25).

22. *Pinus* (*Abies*) *Pinsapo*, Boiss.; Parlatore, D. C. Prod. xvi., p. 422, No. 94 (in part). *Abies Pinsapo*, Boissier, Elench. Pl. Nov. Hisp. p. 84. *Picea Pinsapo*, Loud. Encycl. of Trees, 1041.

Shoots smooth. Leaves inserted singly all round the stem, and projecting nearly straight out in all directions from the shoot, but fewer below than on the upper surface. Leaf linear, short, rigid, scarcely twisted above the large orbicular base. Leaf narrowed above insertion, then widening to its full extent and gradually narrowing towards the elongated sharp-pointed apex; upper surface green, with rows of stomata generally about 6 or 8 in number, and placed rather distantly over the whole upper surface, below with a band of stomata on each side of the midrib, there being about 6 or 7 rows in each band. Leaf from $\frac{1}{2}$ to $\frac{3}{4}$ inch long, and about $\frac{1}{10}$ inch wide. Buds covered with brownish scales, and very resinous.

Transverse section of leaf.—Leaf flattened, but rather tetragonal, only about twice as broad as thick, sides rounded, upper surface convex, below with a prominent midrib. Hypoderma chiefly developed at the margins of the leaf, and above and below the midrib; very much interrupted by the arrangement of the stomata. The resin-canals are placed, one at each side of the leaf, near the margin close to the lower epidermis, but separated from it by a single layer of hypoderm cells. The pallisade tissue is much interrupted on the upper side, and below is the parenchyma with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the whole surrounded by a well-marked sheath.

The figure (Plate 48, fig. 26) is drawn from a specimen supplied to me by Dr. Moore, and grown at Glasnevin.

I have only examined three plants of this species—two from Glasnevin and one from Cirencester. Bertrand places this species in his second section, but I have never found the resin-canals in the parenchyma of the leaf. In the Museum, Royal Botanic Garden, Edinburgh, there is a cone measuring $7\frac{1}{2}$ inches by 2 inches, and to which one or two leaves were attached. It is marked "Picea Pinsapo. From Ronda, in Spain. Mr. Robertson, Trinity, 1859." After the most careful examination, I refer it to Abies bifolia, Murray—the P. lasiocarpa of Hooker.

23. *Pinus* (*Abies*) *Baborensis*, Cosson. *Abies Pinsapo Baborensis*, Cosson, Bull. de la Soc. Bot. de France, viii. 607. *Abies numidica*, De Lannoy, Rev. Hort. (1866), 106 and 168. *Pinus Pinsapo*, Parlatore, in part.

Shoots hairy. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, a few projecting upwards, the base of the leaves on the upper side of the shoot twisted. Leaf linear, base much smaller than in Pinsapo, rapidly widening to its full extent, then contracting rapidly near the blunt or emarginate apex; upper surface dark green, with a few stomata in one or two short rows near the apex of the leaf in the middle line, below with two bands of stomata on each side of the midrib, there being from 7 to 8 rows in each band. Leaves $\frac{1}{2}$ to $\frac{3}{4}$ inch in length, and about $\frac{1}{12}$ inch wide. Buds covered with yellowish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, about $3\frac{1}{2}$ times as broad as thick, sides rather sharp, upper surface slightly convex, with a faint longitudinal furrow, below with a slightly marked midrib. Hypoderma chiefly developed at the margins of the leaf, there being only about a dozen thickened cells placed externally to the resin-canal, and a few scattered hypoderm cells under the upper epidermis, and a few in the middle line below resin-canals, near the margins of the leaf and placed close to the epidermis of the lower surface. The pallisade tissue is well developed on the upper side where not interrupted by the presence of stomata, and below is the parenchyma with intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the whole surrounded by a well-marked sheath.

The figure (Plate 48, fig. 27) is drawn from a specimen supplied by Mr. Syme, Elvaston Nurseries.

I have only examined four specimens of this plant, which differs so strikingly from A. Pinsapo in anatomical characters. Not having seen the cone, I cannot describe it. This species is cultivated in the Royal Botanic Garden, Edinburgh, and at Glasnevin Botanic Garden, under the name of Abies numidica, and is sent to me by Mr. Syme, with both the names "numidica," and "Baborensis."

24. *Pinus* (*Abies*), sp.: Rocky Mountains, Drummond.

Shoots hairy. Leaves inserted singly, and very close together, all round the stem, but bent to form two lateral rows, those on the upper side of the shoot chiefly directed upwards. Leaf linear, twisted at the base, especially on upper side where the leaf is twisted half a turn, base orbicular, width of leaf rather uniform, apex blunt, the margin of the leaf sharp, upper surface dull green, with no stomata, below with a band of stomata on each side of the hardly prominent midrib, there being from 5 to 7 rows in each band. Leaves from $\frac{1}{4}$ to $\frac{3}{4}$ inch long, and about $\frac{1}{12}$ inch wide. Buds covered with yellowish-brown resinous scales.

Transverse section of leaf.—Leaf flattened, about $3\frac{1}{2}$ times as wide as thick, sides not rounded, but with a sharp transparent margin, upper surface with a longitudinal furrow, below with the midrib not prominent. Hypoderma well developed, forming an interrupted band from the outer margin of the resin-canal of one side, under the epidermis of the upper surface, to the resin-canal of the other side; the hypoderma is also developed under the fibro-vascular bundle. The resin-canals are placed at each side of the leaf, close to the lower epidermis. The pallisade tissue is well developed on the upper side, and below is the parenchyma with well-marked intercellular spaces communicating with the stomata.

Fibro-vascular bundle double, the parts placed close together, with a few thick liber-like cells above and in the middle. The whole is surrounded by a well-marked sheath.

The resin-canal has a double wall—the inner cells smaller and with thin walls, the outer larger and with thick walls; this thick-walled layer being in contact with the lower epidermis.

Only one plant of this species has come under my notice. It has been long cultivated in the Royal Botanic Garden, Edinburgh, and was sent to me by my father, marked "Picea sp., California, old tree." The unique plant in the Edinburgh Garden was raised from seed sent from the Rocky Mountains by Drummond. The cone being unknown, I have not attempted to name it.

The figure (Plate 49, fig. 28) is drawn from the plant in the Edinburgh Garden.

The leaf is somewhat like that of P. pectinata, but the plant is not a handsome one.

II. PSEUDOTSUGA, Bertrand; Carrière (in part). Abies, Auct. Tsuga, Carrière. Keteleeria, Carrière.

1. *Pinus* (*Pseudotsuga*) *nobilis*, Douglas, MSS.; Parlatore, in D. C. Prod. xvi., pt. ii., p. 419, No. 89.

Shoots covered with fine hairs. Leaves inserted singly all round the stem, very close together, the leaves on the lower side of the shoot directed laterally by being curved outwards, but not twisted at the base; those on the upper side of the shoot all directed upwards. Leaf rigid, linear, more or less falcate, with an obtuse apex, upper surface variable, sometimes with numerous stomata, the whole surface being pale in colour, at other times stomata less numerous, or even wanting, and the colour darker; beneath with a band of stomata on each side of the midrib, between the midrib and the resin-canal, sometimes with stomata between the external margin of the resin-canal and the edge of the leaf, there being 5 to 7 rows of stomata in each of the bands between the midrib and resin-canal. Leaves about 1 to 1½ inch in length, and about $\frac{1}{12}$ inch wide. Buds small, dark-coloured, and covered with resin.

Transverse section of leaf.—Leaf broadly triangular, three times broader than thick, sides rounded, upper surface with a central longitudinal furrow, below with a prominent midrib. Hypoderma conspicuous, a single layer, rarely a double layer, at the rounded margin of the leaf; a number of hypoderm cells above, under the longitudinal furrow, and a considerable mass two or more cells thick at the prominent midrib below; the hypoderma is interrupted above between the central furrow and the margin by the presence of stomata. The resin-canals are two in number, placed close to the under side of the leaf, and generally about half-way between the midrib and the margin of the leaf, a small cluster of hypoderm cells often placed below the resin-canal. Between the midrib and the resin-canal, on each side, inferiorly, the stomata are developed and the hypoderma is wanting. Between the resin-canal and the margin of the leaf the hypoderma is either continuous or interrupted by the presence of a few stomata. The pallisade parenchyma is scarcely developed at all, owing to the presence of stomata on the upper surface of the leaf.

Fibro-vascular bundle single, and surrounded by a well-marked sheath.

The figure (Plate 49, fig. 29) is drawn from a specimen supplied to me by my father, and cultivated in the Royal Botanic Garden, Edinburgh. Another specimen is figured (Plate 49, fig. 29 a) which was sent to me by my father as Picea amabilis, Douglas.

Pseudotsuga nobilis is a bifolious species, the leaves on the cone-bearing shoots being very like those of magnifica. Indeed it is very difficult, even in cone-bearing specimens, to separate the one from the other anatomically.

I have examined many specimens of nobilis from Glasnevin, Edinburgh, and from Mr. Syme of Elvaston, both of old and young plants. Many native specimens have also been examined, one from Douglas, in Kew Herbarium, "P. nobilis, Sabine. On the high mountains at the Grand Rapids, on the Columbia River, and near the base of Mount Hood, 1825;" several specimens from Jeffrey; one in Kew Herbarium, and two in the Edinburgh collection. One of these is No. 398, "Chastey Bull, U. California, Lat. 41°, elevation 9,000 feet, Oct. 12, 1852." The leaves on the cone-bearing shoots of this specimen are remarkably like those of P. magnifica, but the long projecting scales of the cone show that it is not magnifica. There is also a specimen of nobilis from the Cascades of Columbia, Dr. Gardener.

The leaves of the type specimen of P. amabilis, Sab., Douglas, sent to me by Professor Oliver are those of P. nobilis (Plate 49, fig. 29 b), but may be those of magnifica.

2. *Pinus* (*Pseudotsuga*) *magnifica*. *Abies magnifica*, A. Murray, Proc. Royal Hort. Soc. London, iii. p. 318.

Shoots covered with fine hairs. Leaves inserted singly all round the stem, very close together, leaves on the lower side of the shoot directed laterally by being curved outwards, but not twisted at the base, those on the upper side of the shoot rather closely appressed, not twisted; upper side of leaf towards the branch, and directed towards the apex of the branch, almost covering the shoot. Leaf rigid, linear, more or less falcate, with an obtuse or rather bluntly-pointed apex, upper surface of leaf with numerous rows of stomata, often with 8 or more rows, and giving the leaf a whitish appearance; beneath with a band of stomata on each side of the midrib, there being from 4 to 6 rows of stomata in each band. Leaves about 1 to 1½ inch in length, and about $\frac{1}{12}$ inch wide. Buds small, dark-coloured, and covered with resin.

Transverse section of leaf.—Leaf slightly quadrangular, rather more than one-half as thick as broad, sides rounded, upper surface with a central ridge, below with a prominent midrib. Hypoderma well developed, a single or sometimes a double layer, at sides, below epidermis of midrib, and a few below the ridge on upper side. The hypoderma is interrupted above between the ridge and the margin, by the presence of the stomata. The resin-canals are two in number, placed close to the under side of the leaf, and generally about half-way between the midrib and the margin. Between the midrib and the resin-canal on each side inferiorly, the stomata are developed, and occasionally a row of stomata is seen between the resin-canal and the margin of the leaf. The pallisade parenchyma is scarcely developed, owing to the presence of the stomata.

The fibro-vascular bundle is single, and surrounded by a well-marked sheath.

The figure (Plate 49, fig. 30) is drawn from a specimen kindly supplied to me by Mr. Anthony Waterer, Knap Hill Nursery, near Woking, Surrey.

I have examined twelve specimens of this species—six living, and six dried. The living plants were from Edinburgh; from Mr. Syme, Elvaston Nurseries; from Mr. Anthony Waterer, Knap Hill Nursery; and from Glasnevin; while the dried specimens were from Kew Herbarium, and Edinburgh Museum. It is cultivated in Edinburgh under the names robusta and magnifica. The specimen marked "robusta" has the following note by my father: "The piece of P. robusta is from a layer taken from the original plant sent home by Douglas;" and he adds, "I think it likely that, in certain soils, P. nobilis, robusta, and magnifica, may all turn out to be the same, although distinct in the garden here." Two of the specimens were raised from seeds sent home by Jeffrey. The specimen in Glasnevin was a small very unhealthy plant from Perth Nurseries, and was cultivated under the name of Picea amabilis. The specimens from Mr. Syme and Mr. Waterer were correctly named magnifica. There are three specimens of this species in the Kew Herbarium, one marked "Sierra Nevada, L. California, W. Lobb;" figured (Plate 49, fig. 30 a), and two marked "California, H. Low, Esq., Clapton." These are, I believe, the types of Mr. Murray's magnifica. There are three specimens in the Edinburgh collection; one is marked "Picea robusta magnifica, 1480, Jeffrey." The cones are 6 inches long and 2 inches wide. The bract is long, but not projecting, and has an evident relationship to P. nobilis. The second specimen in the Edinburgh Museum is marked "Pinus, sp. nova, from California, P. Lawson & Son." The cone is 9 inches long by 2½ inches wide, and is bent slightly. The third is marked "P. magnifica robusta, 1480, Oregon, Mr. Jeffrey, 1853." The cone is 8½ inches long by 2½ inches wide, and is slightly bent. This is the species mentioned in the Trans. Bot. Soc., vol. vi., p. 370, by Mr. A. Murray under the name of campylocarpa.

It is certain that this species was sent home by Douglas, as it has long been cultivated in the Edinburgh Botanic Garden, under the name of robusta, the plant being a layer of Douglas's unique specimen. It was also sent by Jeffrey, who called it amabilis, Douglas, and I have no doubt whatever that Jeffrey was perfectly right in so naming it.* The cone is exactly like that of P. lasiocarpa, Hook. (bifolia, Murray); and one of the specimens named in the Edinburgh Museum "P. magnifica robusta, 1480, Oregon, Mr. Jeffrey, 1853," is bifolia of Murray. It has also been sent to Low by Mr. Lobb, and described by Mr. Murray under my father's MSS. name of magnifica.

3. *Pinus* (*Pseudotsuga*) *Davidiana*, Bertrand, Anat. Compar. des Gnét. et des Conif. p. 82.

This species is from Thibet, and is described by Bertrand, but I have not seen it. According to Bertrand it is allied to Pinus Fortunei, but has stomata on both sides of the leaf.

4. *Pinus* (*Pseudotsuga*) *Fortunei*, Parlatore, D. C. Prod. p. 430, No. 112. *Abies Fortunei*, A. Murray, Proc. Hort. Soc. Lond. iii. 421 (1862). *Pseudotsuga Jezoensis*, Bertrand, *op. cit.* p. 83. *Picea Jezoensis*, Carr. (?)

Shoots hairy. Leaves inserted singly all round the stem, scattered, forming two lateral rows. Leaf linear, twisted above the base, widest above the twist, remaining tolerably uniform until about $\frac{1}{3}$ of length from apex, then narrowing into a sharp projecting point; upper surface dark-green, with no stomata (rarely a few near the apex of certain leaves), beneath with a band of stomata on each side of the midrib, there being about 16 rows of stomata in each band. Leaves from $\frac{3}{4}$ to 1 inch in length, and about $\frac{1}{8}$ inch wide. Buds (?)

Transverse section of leaf.—Leaf flattened, about five times broader than thick, sides rounded, slightly angular near resin-canal, upper side nearly flat, or slightly concave, below with a slightly prominent midrib. Hypoderma well developed, forming an interrupted band running from the resin-canal of one side, under the epidermis of the upper surface, to the resin-canal of the other side: a cluster of hypoderm cells below the midrib. The resin-canals are placed, one at each side of the leaf, close to the epidermis of the under surface, but separated from it by a layer of thick hypoderm cells. The pallisade parenchyma is well developed on the upper side, and below is parenchyma with intercellular spaces communicating with the stomata.

Fibro-vascular bundle single, but sometimes divided into as many as six small portions. Bast cells developed below, and the whole surrounded by a tolerably evident sheath.

The figure (Plate 49, fig. 31) is drawn from a specimen kindly

* See Transactions Edinburgh Botanical Society, xi., p. 326.

supplied to me by Messrs. Veitch and Son, Royal Exotic Nursery, Chelsea.

I have only examined one specimen of this plant, received from Messrs. Veitch under the name of Abies Jezoensis. There is no difficulty in identifying the specimen with Mr. Murray's A. Fortunei, a Chinese species. It is, however, very like the plant sent out by Messrs. Veitch as Abies Veitchii, and I strongly suspect there is some confusion yet to be cleared up about these Japanese plants. Veitchii, of Hort. Veitch, is not Veitchii of Kew Herbarium, but resembles P. Fortunei, excepting that the leaves are smaller. Veitchii (Hort.) may, therefore, be Jezoensis, and thus P. Fortunei must stand as the name of this most interesting plant.

5. ***Pinus*** (***Pseudotsuga***) ***Douglasii***, Sabine, Lamb., Gen. Pinus, 2 ed., vol. iii. tab. 21. *Picea Douglasii*, Link. in Linnæa, xv. 524. *Pseudotsuga Douglasii*, Carr., Trait. Général des Conif. 2 ed., p. 256.

Shoots smooth. Leaves inserted singly all round the stem, but bent so as to form two lateral rows, occasionally a few are directed upwards and downwards. Leaf linear, twisted near the base, which is narrowed to the small insertion, breadth uniform for greater part of length, apex rounded, upper surface bright green, with no stomata, beneath with a band of stomata on each side of the midrib, there being, from 5 to 6 rows of stomata in each band. Leaves from 1 to 1¼ inch long, and about $\frac{1}{16}$ inch wide. Buds covered with yellow resinous scales.

Transverse section of leaf.—Leaf flattened about 2½ times as broad as thick, sides rounded, upper surface with a longitudinal groove, below with a slightly prominent midrib. Hypoderma very variable, in some leaves very well-developed, in others almost absent on upper side. The resin-canals are placed one at each side of the leaf, close to the epidermis of the under side. The pallisade parenchyma is well developed on the upper side, and below is parenchyma with well-marked intercellular spaces. In the parenchyma of the leaf are developed, in North American specimens only, peculiar stellate idioblasts, which ramify between the ordinary parenchymatous cells.

Fibro-vascular bundle single, surrounded by a well-marked sheath.

The figure (Plate 49, fig. 32) is drawn from a specimen supplied by Mr. Syme, which shows the absence of hypoderma in cultivated plants and agrees well with others from Edinburgh and Glasnevin. Plate 49, fig. 32a, represents a specimen of Douglasii from Kew Herbarium. It is marked "Abies sp. nova, Douglasii? Rocky Mountains. Independence Bluff, Nuttall." It has the cone of Douglasii, but the development of hypoderm and idioblasts separates it from all the cultivated specimens I have yet seen. It is the same as Wright's No. 1885, from New Mexico, which Parlatore refers to P. Douglasii. The third specimen figured (Plate 49, fig. 32b.) is Fendler's, No. 829, which Parlatore refers to amabilis. Either the species is variable, or else we have one species in cultivation and another known only by Herbarium specimens, viz., Fendler, No. 829; Wright, No. 1885; and Abies, sp. Douglasii? Rocky Mountains, Nuttall. I am indebted to Prof. Perceval Wright for the opportunity of examining the specimens of Fendler and Wright in the Herbarium of Trinity College. The leaves of the fine old plant of Douglasii, in the Royal Botanic Garden, Edinburgh, have neither hypoderm nor stellate idioblasts.

LV.—A CONTRIBUTION TO THE HISTORY OF DOLOMITE.—THE DOLOMITES OF THE CARBONIFEROUS LIMESTONE OF IRELAND. By EDWARD T. HARDMAN, F. C. S., F. R. G. S. I., of the Geological Survey of Ireland. (With Plates 41 and 42.)

[Read May 8, 1876.]

As Bischof well remarks, "no rock has attracted greater attention than dolomite;" and very many theories as to its origin have been put forward; the principal of which are based on the idea of the metamorphism, in some way, of limestone rocks, varying the means of such changes according to the views of different authors.

(1). Von Buch's supposition involves the introduction of magnesia into limestone, as the result of the eruption of volcanic rocks in the neighbourhood, producing vapours of magnesic chloride.*

(2). Haidinger suggested that the effect was produced by the action of sulphate of magnesia on limestone, sulphate of lime and carbonate of magnesia being formed.† But as this cannot be effected in the ordinary way, it is assumed that under the influence of great heat and pressure it might take place. It will be remembered, however, that most dolomitic deposits of themselves utterly refute such an hypothesis.

(3). Von Morlot put forward a similar theory, having, as he supposed, found that when sulphate of magnesia and carbonate of lime were heated in a sealed tube to a temperature of 392° F., a double carbonate of lime and magnesia was formed, together with gypsum.‡ But Dr. Sterry Hunt has shown that in this case the so-called dolomite was really but a mixture of carbonate of lime with carbonate of magnesia,§ nor did he find that Marignac's‖ substitution of chloride of magnesium for the sulphate yielded any better results.

All these well-known theories not only presuppose in every case the action of igneous rocks, and a high temperature, but also the evolution of gaseous sulphuric and hydrochloric acids, in order to obtain the necessary supplies of magnesia from the eruptive rocks themselves. In our present state of chemical and geological knowledge, it will therefore be doing no violence to the scientific reputation of their originators, to say that they may now be looked upon rather as curiosities of geological literature.

(4). Forchammer appears to refer the formation of dolomite to

* See Bischof, Chem. Geol., vol. iii., 155 *et seq.* Also Chem. and Geol. Essays, T. Sterry Hunt, 44 D., &c., p. 81,—Ann. de Chem. and Phys., xxiii., 296.

† Bischof, *op. cit.*, p. 158.—Pogg. Ann., lxxiv., p. 591.

‡ Bischof, *loc. cit.*, also N. Jahrb. für Min., 1847, 862.

§ Chem. and Geol. Essays T. Sterry Hunt.

‖ For the experiment, see Bischof, vol. iii., p. 159.

the reaction of spring-water, containing a large percentage of carbonate of lime, with sea-water, at a very high temperature.* But this theory, which bears a slight degree of resemblance to that of Hunt (see *post*), will not answer, since many dolomites, e. g. those the carboniferous formation in Ireland, not only are interstratified with limestone, but actually the same bed may be highly fossiliferous limestone in one place, and pass into dolomite in another. Such instances are common, and it is clear that such a rock could not have been deposited from boiling sea-water.

(6). Dr. T. Sterry Hunt apparently endeavours to strike the happy medium between the Wernerists and the Plutonists, but still his theory will be found not to account for the interstratification, and passage into each other of fossiliferous limestones and dolomites. It supposes the reaction of river waters holding in solution carbonate of soda, with sea-water contained in shallow basins, and further decompositions of chloride of calcium and subsequently of sulphate of magnesium into bicarbonates of calcium and magnesium respectively; the former being precipitated first, but that, under certain conditions, a mixture of the two may be precipitated together. "The subsequent action of heat upon such magnesian sediments, either alone or mingled with carbonate of lime, has changed them into magnesite or dolomite."† I am at a loss to see why Dr. Hunt's own objection to Von Morlot's theory does not also apply to this. In both cases only a mixture of the two carbonates is obtained in the first instance, and the element of sufficient heat may be supposed as well in the one case as in the other. But besides this, the whole theory fails altogether to account for the carboniferous dolomites of Ireland: for the facts that it is possible to produce specimens from the same bed, of fossiliferous unaltered limestone, and of true dolomite, and that beds of dolomite lie above and below highly fossiliferous limestone, as I shall show hereafter. Moreover, the number and development of the fossils with which the limestones abound, as well as the general stratigraphical character of the deposits, and the extremely capricious manner in which the dolomites occur, show that they could not have been formed in a series of shallow seas, unless we admit an extraordinary series of changes of level, and of physical features, during the period of the formation of the carboniferous limestone—a position which is quite untenable.

I take the dolomites of the carboniferous limestone as a test of these theories, not only because I am best acquainted with them, but be-

* Bischof, viii., p. 161.—Also, Ann. de Chem. and Phys., xxiii. Also, Report Brit. Assoc., 1849 (Birmingham), Transactions of Sections, p. 36, where an abstract of his views is given.

† Chem. and Geol. Essays, pp. 80–90. On the Chemistry of Dolomites and Gypsums, also pp. 91–92, 309, *et multis aliis*. I should not refer so particularly to this in the present instance, but that Dr. Hunt applies his theory to the formation of "all magnesian limestones."

cause while they are of extremely frequent and extensive occurrence in Ireland, they are also found under perhaps the most favourable conditions for the determining any points with regard to either Plutonism or physical phenomena.

On the subject of Irish dolomites, two valuable papers are extant. Many years ago Dr. Scouler communicated his views on that subject to the Geological Society of Dublin;* his opinion being that dolomite was produced by a metamorphism of the original limestone, and, following Virlet, he considered the change to be readily accounted for by the infiltration of water charged with carbonate of magnesia; which water would at the same time remove some of the carbonate of lime. But an important point in his paper is that he considers dolomite to occur usually near some source of magnesia—either near an igneous or ancient palæozoic rock, or close to a break in the strata, where a thermal spring might have existed. This is a point which I shall presently dwell upon, as many dolomites occur under circumstances which do not agree with any of these conditions, and where the supply of magnesia is far below that of lime.

The reading of the above paper led Dr. Apjohn to make several analyses of Irish dolomites, which he has published in the same journal.† The conclusions he came to as to the origin of dolomites appear to be that they are original formations; first, because they are often fossiliferous, and, secondly, because their composition is definite. At the same time he suggests that some dolomites may have been produced by the solvent action of carbonated water on limestones containing some magnesia, in removing carbonate of lime, until at last the rock would consist of the two carbonates in the correct proportion.‡

Probably the most comprehensive account yet published of the dolomite question is that given by Bischof, who, in his classical work on chemical geology, has discussed nearly all the foregoing views, together with many of those held by other writers. He dismisses as improbable all those which call in the aid of volcanic or Plutonic agencies, and shows that the action of water by infiltration through limestone can alone explain the processes of dolomitization; that is, either by

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* Observations on Beds of Dolomite which occur in connexion with the Carboniferous Limestones in different parts of Ireland. By John Scouler, M.D., &c., Jour. Geol. Soc. Dub., vol. i., pp. 382–5.

† Analyses of some Irish Dolomites. By James Apjohn, M.D., &c. Jour. Geol. Soc. Dub., vol. i., pp. 369 *et seq.*

‡ I am inclined to adopt a modification of the above hypothesis, viz., that the greater part of the carbonate of magnesia was originally secreted along with the carbonate of lime, but that dolomite is a true metamorphic rock—the alterations being due to the extraction of the surplus of carbonate of lime. Some so-called dolomites having the crystalline structure and the obliteration of fossils *en regle*, are by no means of definite composition; they usually contain a considerable percentage of uncombined carbonate of lime, which dissolves out in weak acid.

the action of water holding carbonate of magnesia in solution, penetrating the rock, and depositing carbonate of magnesia, while at the same time removing a portion of the carbonate of lime; or, as he admits, it *may* occur in some cases by the simple removal of carbonate of lime from a magnesian limestone by water containing carbonic acid; the result being, of course, a gradual increase in the proportion of carbonate of magnesia. While admitting this process, which was first suggested by Grandjean, to be possible—as he shows by two experiments, which prove carbonate of lime to be actually more soluble than carbonate of magnesia in water containing a small percentage of carbonic acid—he, however, appears to give the preference to the first process, viz., the infiltration of carbonate of magnesia, and removal of lime.* But there appear to be one or two weak points about this. 1st. That with so little difference in solubility of the two salts, a substitution of one for the other would hardly take place to the extent required.† 2nd. That the lime removed must always be equal—proportionally to their respective atomic weights—to the magnesia deposited, or the rock would increase in bulk. 3rd. That the result would only be a carbonate of lime with carbonate of magnesia deposited in crevices or interspaces left by the removal of the excess of carbonate of lime; and 4th, that there is a difficulty sometimes in imagining a sufficient supply of magnesianized water in localities where, as in the central plain of Ireland, there are none but limestone rocks, the water from which, containing a much larger quantity of lime than magnesia, could hardly, therefore, produce the supposed effect; yet all these limestones are highly dolomitic.

Any alteration that has taken place in these must have been entirely produced by surface-water, or rain-water, which could contain little or no constituents capable of affecting the limestone rocks, except carbonic acid. To the action of this agent I attribute the alteration which most of the Irish limestones have undergone in their passage into dolomite. At the same time, I think it quite possible that water *highly charged with carbonate of magnesia*, which may be the case if it has percolated a *magnesian rock*, may deposit the magnesia while it removes the lime, and thus aid in the metamorphism; but, as I shall show hereafter, waters containing any appreciable amount of carbonate of magnesia are rare; and after all, as Bischof shows, in such a case the chief work is done by the action of the carbonic acid.‡

If we suppose a limestone rock, containing, as very many limestones do, carbonate of magnesia to the extent of 12 per cent., to

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* Chem. Geol., vol. iii., p. 164.

† Bischof failed, after "taking much pains," to effect the mutual decomposition of carbonate of lime and carbonate of magnesia. In one case he digested fragments of chalk with pure carbonate of magnesia, for several years, without any effect.—*Op. cit.*, vol. iii., 167.

‡ Chem. Geol., vol. iii., p. 174. (In effect, although not in these precise terms).

be subjected to the action of carbonated water, assuming this to be capable of removing a greater quantity of carbonate of lime than of carbonate of magnesia—*in proportion to that in the rock*—it is clear that in the process of time we should have the percentage of magnesia becoming greater and greater, until at last the rock approached in chemical composition to a true dolomite. Moreover, the removal of carbonate of lime would give rise to a cavernous or porous condition of the rock, and the calcareous water trickling over the sides or into these cavities would result in a deposit of crystals of more or less pure carbonate of lime therein. Every one who has paid any attention to this subject is, no doubt, aware that the above are characteristics of dolomite limestone.

Upon the above assumption, which I have now good reason to believe a certainty, I based a number of experiments with the view to ascertain whether, when placed under conditions as near as possible to those obtaining in nature, limestone does not yield more lime than magnesia, when submitted to the action of carbonic acid in water.

At the time I had not Bischof's book at hand, and all the statements I had seen gave just the opposite opinion. I was subsequently much pleased to find that Bischof's two experiments* are confirmatory of my results, and they being unknown to me then could have had no biasing effect.

It is without exception received, I believe, that carbonate of magnesia is much more soluble than carbonate of lime; but the few experiments I have made on this point do not appear to show any great difference; and I have been led to imagine, therefore, that its behaviour in the presence of ammonia salts may have been taken by some to represent its character under other circumstances. In the process of chemical analysis, when it is desired to separate magnesia from lime, a little chloride of ammonia is added to the solution, and an alkaline carbonate then precipitates the lime with just a trace of magnesia. If, however, ammonia is not previously added, both salts are almost instantly precipitated by carbonate of soda.

But, even admitting that carbonate of magnesia is *per se* a trifle more soluble than carbonate of lime, it is certain that, when both are mingled together in a limestone rock, just the reverse takes place when they are subjected to the action of carbonated water. My experiments will show this. Before proceeding to refer to them, however, I should like to mention the results obtained by previous experimenters.

Professors W. B. and R. E. Rogers, at the Meeting of the British Association at Birmingham, in the year 1849, read a paper on some experiments as to the solvent power of carbonated water on various minerals.† In the course of their experiments they were led to inves-

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* See *post.*

† "On the Decomposition and Partial Solution of Minerals, Rocks, &c., by pure water, and water charged with Carbonic Acid." By Prof. W. B. Rogers, and Prof. R. E. Rogers. Rep. Brit. Assoc. 1849; Trans. of Sections, p. 40.

tigate *the comparative solubility of carbonate of lime and carbonate of magnesia in carbonated water.*

The means which they employed were—1st, what they designate as the method with the *tache*, consisting in digesting for a few minutes a small quantity of the mineral, *finely powdered*, on a filter with carbonated water, and then collecting the filtrate and examining it for lime and magnesia. 2nd. By agitating briskly for some time, in a large glass bottle containing carbonated water, a quantity of the mineral, in this case also *finely powdered*. The water was then evaporated, and the residue examined. In both these cases, magnesian limestone so treated yielded a larger quantity of carbonate of magnesia than of carbonate of lime, proportional to their relative amounts in the rock; and the Professors Rogers infer that in nature this process would result in the limestone *becoming less magnesian, instead of approaching to a dolomite, as is generally maintained.*

Now I wish to point out that the process sketched above cannot by any means be held to represent that which takes place in nature. The very act of powdering the dolomitic limestone has destroyed any value the experiment might otherwise have had. We do not find rocks *in situ* thus prepared for the invading action of carbonic acid; and we know that dolomites entirely, and magnesian limestones to a great extent, resist the action of much stronger acids than a merely carbonated solution, so long as they remain solid; but once they are powdered up, they are readily dissolved with evolution of carbonic acid. In effect, this fact is made use of in testing rocks in the field; dolomitic limestone being scarcely affected at all by moderately dilute hydrochloric acid, and can therefore be readily distinguished from ordinary limestone.

I do not know if the amount of magnesium carbonate obtained by the above method was quantitatively determined by Professors Rogers, as I have not been able to consult their detailed paper in the American Journal of Science; but it is curious that Bischof obtained just the contrary result to theirs, in the two experiments I have already referred to, although his method of proceeding is essentially the same. His results agree very well with my own.

Bischof's Experiments. The composition of the limestone being ascertained, a portion was powdered finely, and placed in water for 24 hours. The water was then examined, and proved in the cases tried to contain either no trace, or a very small one, of magnesia. I shall copy one of these for example, as it will be useful to compare with my results.

Black Magnesian Limestone. From Stadtbergen.*

I. ANALYSIS.

Carbonate of lime,	84·57
,, magnesia,	11·54
,, iron,	1·15
Silica and carbon,	1·36
	98·62

II. AMOUNT OF CONSTITUENTS DISSOLVED *in* 24 *hours, from* 6660 *grains.*

	Grains.
Carbonate of lime,	4·29
Carbonate of magnesia,	no trace.

There appears to be, for the quantity taken, and the time occupied, more carbonate of lime dissolved than occurred in any of my experiments; however the powdering of the rock might give rise to this. But this important fact still remains, that, when treated with a weak solution of carbonic acid, limestone yields more carbonate of lime proportionally than carbonate of magnesia.

Perhaps it is well to notice here the curious difference that pressure makes, not only in the solvent power of carbonic acid, which is increased, but in its relative effects on the two carbonates. It appears certain that, under the ordinary atmospheric pressure, and in such proportions as it occurs in most surface or even underground waters, it will chiefly attack the lime, while under a high pressure, and in large quantity it seems to confine its attentions, I may say, strictly to the magnesia. Advantage has actually been taken of this property to procure salts of magnesia, such as the sulphate, from dolomite; the process consisting in submitting the rock, finely ground, with water, to the action of carbonic acid, under a pressure of about four atmospheres. It is then found that nearly all the carbonate of magnesia is removed, without admixture of carbonate of lime.†

This is worth noting, as it may serve to account for the large quantities of carbonate of magnesia which are occasionally, *but not often*, found in spring waters; and may also explain the production of deep-seated dolomites by infiltration of magnesian water.

As it is, however, with dolomites formed under circumstances not taking in the element of pressure we shall have to deal at present, I shall not enter more fully into the above matter just now; but proceed to describe the experiments I have referred to.

It appeared to me that if it could be proved by some process as

* Bischof, *op. cit.*, vol. iii., p. 195.
† Dingl. Polyt. J., ccix., 467.—*Abs.* Jour. Chem. Soc., vol. xii., p. 96.

nearly as possible akin to that which goes on in nature, that more carbonate of lime is dissolved than carbonate of magnesia by a weakly carbonated solution, it would go far towards solving the question, as to the formation of some dolomites.

The process I adopted was very simple. A limestone was selected which contained a fair percentage of magnesia, it was analysed, and the proportions noted. A portion of the rock was then broken up into small fragments, somewhat less than half-an-inch across. These were placed in a jar open to the atmosphere, with distilled water, and carbonic acid was passed in. A piece of litmus paper was placed in the jar, and the flow of gas was stopped as soon as this became reddened. Whenever the paper showed any indication of returning to its original tint, the solution was again saturated with the acid, and so on. In this way an over saturation with acid (which might have had too energetic an effect on the rock) was prevented, and the whole experiment brought as near to nature as is possible in a laboratory, in having a mildly carbonated solution acting on *surfaces* of the rock, and not on minute particles.

With the process carried on in this manner, I found the action of the carbonic acid to be extremely slow, compared with the results obtained from powdered rock by other experimenters, several days being required to dissolve sufficient of the carbonates for estimation; but in every case the carbonate of lime was much in excess. Some of my experiments were merely tentative, and are not worth recording; but I shall now mention the details of some of the more important ones.

No. I.—Limestone from the interior of the Cave of Dunmore, Co. Kilkenny. A light grey compact magnesian limestone.

Analysis.

Mean of two specimens.

Carbonate of lime,	68·21
Carbonate of magnesia,	24·00
Peroxide of iron, ,, alumina,	4·32
Silica,	1·92
Carbonate of iron,	0·90
	99·35

It will be observed that this is a remarkably pure limestone, the amount of silicates, &c., being very small. The rock is evidently becoming dolomitic, for the limestone above and around the cave is not by any means highly magnesian.

Exp. 1.—A quantity of the limestone was broken up small. 110 grains were taken and placed in a jar with distilled water, and carbonic acid gas was passed in almost continuously for 72 hours. At the expiration of that time the solution was carefully filtered off and examined. It contained both carbonate of lime and of magnesia, but in extremely small quantity, viz.:—

Carbonate of lime, ...	0·05 grains.
Carbonate of magnesia, . . .	0·007 ,,

Calculated now according to the percentage of carbonate of lime in the rock, *i. e.*, 68·21, the above gives the respective proportions dissolved to be—

Carbonate of lime, ...	68·21
,, magnesia, . . .	9·32 only,

or less than half the proportion of carbonate of magnesia actually in the rock. It is clear, therefore, that this operation, continued sufficiently long, must result in a dolomite.

Exp. 2.—About the same quantity of the Dunmore limestone was taken—110 grains, and placed in a jar with water as before. Carbonic acid gas was then passed in, nearly continuously for 44 days. For about a week or so of that time no gas was passed in, but for the most part of this experiment the water was supersaturated with the acid, the result of which will be presently seen.

The liquid, having been carefully filtered off, evaporated to dryness, and the residue examined yielded the following result:—

Carbonate of lime, ...	1·04 grains.
,, magnesia, . . .	0·306 ,,
,, iron, ...	a trace.
Total dissolved, . .	1·346

Calculating again according to the proportion of carbonate of lime in the rock, we have—

Carbonate of lime, ...	68·21
,, magnesia, ...	20·06

I attribute the high percentage of magnesia carbonate dissolved in this instance to the supersaturated condition of the carbonic acid solution, which was allowed to become quite in excess of anything that could occur in nature. Nevertheless, it is evident that the carbonate of lime was the most rapidly dissolved in this case also.

It seems remarkable also that so small a portion of the limestone was dissolved after such long continued action. However, this was confirmed in other experiments, and I apprehend it is due to the magnesian character of this rock. It is certain that the action of small quantities of carbonic acid on limestones is in an inverse ratio to the amount of magnesia in them—dolomites being almost unassailable. Experiments 4 and 5 will show how well this is borne out.

Exp. 3.—As the limestone used in the last was hardly diminished at all, it was again covered with distilled water, and carbonic acid passed in. Care was taken to keep the solution just slightly acid, and to avoid the error of Experiment 2. The action was continued for 20 days. The solution was then filtered off, evaporated, and examined as before, with the following result:—

Carbonate of lime, ...	0·55 grains.
,, magnesia, . . .	0·07 ,,
,, iron, ...	a trace.
Total dissolved, . .	0·62

This experiment bears out the second very well, as to the total quantity of substance dissolved, the time occupied being half of that, and the total dissolved about half also. The proportion of magnesia is less, however, no doubt owing to the precaution of using a weak solution of acid. The proportion calculated as before would give—

Carbonate of lime, ...	68·21
,, magnesia, . . .	9·04

This agrees almost exactly with the proportions determined in Experiment 1.

No. II.—Limestone from the breccia of the roof of the Shandon Cave, Dungarvan, Co. Waterford. A bluish-grey fossiliferous limestone, apparently not very magnesian. It turns out, however, to contain a rather large proportion of carbonate of magnesia.

Analysis.

Carbonate of lime, ...	79·89
,, magnesia, . . .	12·71
,, iron, ...	trace.
Peroxide of iron, ... Alumina, ...	} 4·08
Silica and insoluble residue, .	3·40
	100·00

Exp. 4.—187 grains of the limestone, broken in small pieces as before, were placed in a large jar with distilled water,* and carbonic

* It should be noted that in all the experiments except No. 1, the same quantity of water was used, viz., about 20 oz.; care being taken to supply loss by evaporation.

acid passed in: supersaturation with the acid was guarded against, and the limestone was allowed to remain in the water for 40 days. The liquid was then examined, and it yielded:—

Carbonate of lime,	. . . .	3·59 grains.
,, magnesia,	. . . . .	0·47 ,,
,, iron,	. . . .	trace.
		4·06

This, calculated according to the percentage of carbonate of lime in the rock, would give for the proportions dissolved:—

Carbonate of lime,	. . . . . .	79·89
,, magnesia,	. . . . .	9·34
		89·23;

there being in the rock as much as 12·71 of carbonate of magnesia: so that in this case also it will be seen that the result must be a gradual increase in the amount of that constituent.

It will be noticed also, that although the experiment was not continued for quite so long a period as No. 2, the total amount of carbonates dissolved is more than double.

Exp. 5.—The fragments of limestone from Shandon, used in the last experiment, were subjected to the further action of carbonic acid, in the same way, the action being allowed to go on for 20 days. The solution being then examined yielded the following:—

Carbonate of lime,	. . . . . .	1·15 grains.
,, magnesia,	. . . . .	0·11 ,,
,, iron,	. . . .	a trace.
Total dissolved,	. .	1·26

Calculated as before, the percentage dissolved will be in the proportion—

Carbonate of lime,	. . . . . .	79·89
,, magnesia,	. . . . .	7·64
		87·53,

a result sufficiently near that of the former experiment. The total amount dissolved in this case is not quite half that dissolved in double the time in the former experiment.

These investigations prove the following points:—

1°. That in a weak solution of carbonic acid, limestones in the mass, not powdered, yield more carbonate of lime than of magnesia.

2°. That in equal times the more magnesian limestones are least susceptible to the action of such a carbonic acid solution.

3°. That other things being equal, the relative proportion of the two bodies dissolved appears to remain fairly unaffected by the time occupied in the experiment.

I should mention that the experiments detailed above are not the only ones made which verified the above points: but it would be tedious and uninteresting, I conceive, to enter into particulars of all of them.

[*Note added in Press.*—In order to test the effect of more energetic acids, the following experiment was made since the foregoing was written.

A piece of dolomite from Ballyfoyle, near Kilkenny, having the following composition, was taken:—

ANALYSIS.

Carbonate of lime,	55·48
,, magnesia,	43·52
Ferric oxide and alumina,	0·68
Silica, &c.,	0·34
	100·02

SPECIFIC GRAVITY, 2·73.

Being broken up small, pieces were carefully selected, so as to be as free as possible from other minerals, such as carbonate of iron, calcite, &c. 141 grains were placed in a beaker with distilled water, to which a little hydrochloric acid was added. The solution, although weak, caused copious effervescence *from the interstices.* The experiment was continued for about a month—a few drops of acid being added, when test-paper denoted that the acid previously added had been neutralised. Having left home for a fortnight, I found on my return that a flocculent precipitate—probably carbonates of iron and lime—had been thrown down, no doubt induced by absorption of carbonic acid from the air. The addition of a few drops of acid dissolved this. The whole was then allowed to stand for more than another month; at the expiration of which time a little acid was added to dissolve the precipitate that had again formed—but not enough to affect the undissolved dolomite — and the solution was filtered off. Both solution and undissolved residue were then carefully analysed.

The following Table gives the result:—

	I. In undissolved Residue.	II. In Solution.	III. Total.
	Grains.	Grains.	Grains.
Carbonate of lime, . .	38·50	40·10	78·60
,, ,, magnesia, .	31·25	29·65	60·90
Ferric oxide and alumina,	0·63	0·33	0·96
Insoluble residue (silica, &c.), ...	0·48	—	0·48
	70·86	70·08	140·94

The above reduced to Percentage Composition.

	I.	II.	III.
Carbonate of lime, . .	54·33	57·22	55·76
,, ,, magnesia, .	44 10	42·31	43·20
Ferric oxide and alumina,	0·88	0·47	0·68
Insoluble residue, . . .	0·67	—	0·34
	99·98	100·00	99·98

So far from the carbonate of magnesia being the most soluble here, it will be seen that the result of the experiment has been actually to bring the composition of the magnesian limestone nearer to that of true dolomite than it was before. The proper proportions being about 52·08, Ca CO_3 to 46·50, Mg CO_3. It will also be observed from column II. that the carbonate of lime dissolved was much in excess of carbonate of magnesia.]

It had, some time before, struck me that if magnesian carbonate were really more soluble under the circumstances which occur in nature than carbonate of lime, we ought to find some account of it in the stalactites and stalagmites so invariably found where water has percolated through limestones. It has been long known that these accumulations are usually free from magnesia, and the Messrs. Rogers, in the paper already cited, refer to this as a proof of the greater solubility of the carbonate of magnesia, since they say the latter is carried off in solution, while the carbonate of lime is deposited.* Now it is difficult to imagine that all the carbonate of magnesia would so completely disappear, and one would rather suppose

* Bischof, in describing the mode of formation of the sprudelstone from the Carlsbad hot springs, appears to coincide with this opinion, since he considers the magnesia to be carried away wholly in solution. In this case, however, the water has a ready means of escape, and the deposition of carbonate of lime is due to loss of carbonic acid, and not to evaporation.

the possibility of a few layers of it in stalactites, had it ever been held largely in solution. At any rate, the drippings, which would under such a supposition be charged with carbonate of magnesia, falling on the floor, say of a cave, if they produced any stalagmite, should produce a magnesian one, or one containing a very considerable proportion of that body. It appears, however, that neither the one nor the other contains any appreciable amount of it at all, and even those from magnesian limestones follow the general rule. I can hardly think that, in the case of *stalagmites*, some of the magnesian carbonate, if it had been present in the solution which formed them, would not remain. It ought, certainly, to be found in the upper layers, as stalagmite is by no means porous, but this seems not to be so. I am speaking now of stalagmite formed in places where the water could have had no ready means of escape except evaporation.

On the other hand, the argument as to the most soluble being carried away entirely ought to hold good as respects the carbonates of lime and iron. As the latter is least soluble of all, whenever it occurs in stalactites they should consist nearly entirely of it, if the above idea were correct. A great amount of the more soluble lime-salt would be carried off while the carbonate of iron was crystallising, and we would have stalactites containing usually a very large percentage of iron; but this is rarely the case.

As analyses of stalactitic bodies are not numerous, I give those of two or three which I have examined.

No. I.—Stalagmite—from the floor of Dunmore Cave, Co. Kilkenny.

A part of the upper layers where the thickness was at least 6 inches.

ANALYSIS.

Carbonate of lime, ...	97·12
,, magnesia, ...	0·79
,, iron, ...	1·86
Peroxide of iron, alumina, ...	0·23
	100·00

This stalagmite was of a dirty grey colour, and apparently full of impurities.

No. II.—Stalagmite from roof breccia of the Shandon Cave, Dungarvan :—

This stalagmite forms an extremely pretty mass, of a clear cream-colour, and is well crystallized. It occurs in large quantity, and often in considerable masses amongst and underneath the breccia. The specimens examined adhered to the under side of the limestone, a portion of which was analysed and experimented on. (See Experiments 4 and 5.) It is therefore reasonable to suppose that its materials were derived from that very magnesian rock.

ANALYSIS.

Carbonate of	lime, ...	99·25
,,	magnesia, ...	0·70
,,	iron, ...	trace
		99·95

The iron present was hardly sufficient to give the pale yellow colour to the mass. The parent rock of these stalagmites being so very magnesian, we should expect to find a very appreciable amount of magnesia in them if, as is thought by so many, the carbonate of magnesia in limestone rocks is so very soluble. But what can have become of it? for I shall show presently that the waters of limestone districts contain a very trifling amount of magnesia.

It is hardly conceivable that, were the carbonate of magnesia in such rocks the most soluble in weak carbonic acid, there should be barely traces of it in these deposits; and from this circumstance, as well as from its scarcity in spring waters, we should rather be led to infer its greater insolubility, even without the experiments I have brought forward.

No. III.—Stalactites from a highly magnesian limestone, Railway bridge, Thomastown, Co. Kilkenny.

ANALYSIS.

Carbonate of	lime, ...	99·25
,,	magnesia, ...	0·50
		99.75

One link in the chain is still wanting, viz., the analysis of waters which have undoubtedly passed through such limestones as the above-mentioned, and which have deposited stalactitic matter. Some information on this point I hope to have a future opportunity of conveying to the Academy, as I have commenced some analyses of the waters which have dripped from the roof of the Cave of Dunmore. But I am compelled for the present to fall back on the accounts of various waters already published by different authors.

In Dr. Sterry Hunt's paper on the Chemistry of Natural Waters,* a series of nineteen analyses of various American waters is given, in five of which carbonate of lime is much in excess of carbonate of magnesia, and in some others chloride of calcium is in very large proportion to that of magnesia. In the remainder, however, the amount of carbon-

* *Op. cit.*, p. 92, *et seq.*

ate of lime and of carbonate of magnesia is about equal. These are the only analyses of water I have seen in which the amount of magnesian salts at all approaches that of the lime salts.

In the valuable abstracts of chemico-mineralogical papers published in the Journal of the Chemical Society, from vol. ix. to vol. xiv., inclusive, I find very many analyses of mineral waters, with one or two exceptions European, ordinary river water, chalybeate and thermal springs, &c. In all of these the carbonate of lime is in great excess of that of magnesia; the chlorides also occupy the same relative position. In all these analyses there is no instance to the contrary. The proportions are very variable of course, in some cases carbonate of magnesia being altogether absent. The lowest proportion in which it is stated in any of these is*

Carbonate of lime, ...	145
" magnesia, ...	7

The highest is,† for total lime and magnesia salts: they are calculated only as oxides—

Lime (Ca O.)	74·94
Magnesia (Mg O.)	20·54

and the average proportion appears to be about 14 to 1.

About thirty or forty analyses are included in the above *resumé*. In no single instance was carbonate of magnesia in excess of carbonate of lime. All these scattered analyses are the more valuable in their agreement on the point I am urging, from their authors having, apparently, no particular theory to bring forward, and, though taken at random, the persistence in the larger amount of lime salts is very marked. I may now refer to the capital table of analyses of river waters given by Bischof,‡ which includes forty-eight examples, in every one of which carbonate of lime is very largely in excess of that of magnesia. These range as follows:—

Carbonate of lime, . .	1·28 to 18·23	In 100,000 parts.
" magnesia, .	0·09 to 1·47	

In many cases no carbonate of magnesia is recorded at all, even where the corresponding lime salt is so high as 26·2, nor is there in any case a large proportion of the more soluble salts of magnesia, sulphate, or chloride. This shows, therefore, that carbonate of magnesia

* Chalybeate spring at Sellafield, near Whitehaven. W. H. Watson, Chem. News, xxxii., p. 11. *Abs.* Jour. Chem. Soc., vol. xiii., p. 1169.

† Rhine water, near Köln, Dr. Vohl. *Abs.* Jour. Chem. Soc., vol. ix., pp. 213–14.

‡ *Op. cit.* i., pp. 76, 77.

is nowhere so abundant in surface-waters as some writers on this subject apparently consider, and that we are justified in rejecting the statement that most dolomites are formed by infiltration of magnesian water, at least until more evidence on that head is produced.

It would appear, in fact, to be more reasonable to assume that the lime in limestone rocks was conveyed into them by percolation of mineral waters, than that the magnesia of dolomitic rocks so originated.

A very important paper bearing on this subject, and perhaps the only one in which it has yet been definitely treated, is that of E. V. Gorup-Besanez, on the Dolomite Springs of the Jura.* The author gives a series of analyses of waters of springs rising in the Jura, many of them in the neighbourhood of, or as it would appear, actually rising from, dolomitic limestones; and he finds that in some cases the carbonate of lime, and of magnesia, are actually present in dolomitic proportions. For instance, two springs give the following—

	I.	II.
$Ca\,CO_3$, . . .	57·32	57·21 †
$Mg\,CO_3$, . . .	42·68	42·79

This is very remarkable indeed.

Some of the analyses gave, however, the following:—

$Ca\,CO_3$, ...	88	89	70	68
$Mg\,CO_3$, ...	12	11	30	32

and the mean of the analyses was—

$Ca\,CO_3$, ...	53·71
$Mg\,CO_3$, ...	14·29

The author is led to agree, therefore, with Bischof in the opinion that, from *perfectly formed dolomites*, water containing carbonic acid dissolves out $Ca\,Co_3$ and $Mg\,Co_3$ together in fixed proportions,‡ but does not coincide with him in the idea that the presence of magnesite in cavities of the magnesian limestone prove the dolomite to be a perfectly formed one,§ since crystalline magnesite would not be deposited from such solutions. He considers the geological formation of dolomite a subject yet quite unsettled, and is opposed to Bischof's admission

* Ann. Chem. Pharm. Suppl. Band. viii., 230–242. *Abs.* Jour. Chem. Soc., vol. x., p. 59.

† In all the analyses, other constituents proved too trifling for notice.

‡ See Bischof, Chem. Geol. iii., p. 196.

§ See Bischof, *op. cit.*, iii., p. 196.

that carbonated water may dissolve out only carbonate of lime until, at last, the proper dolomitic proportions are reached.*

It will be noticed, however, that in the analyses given in the paper just referred to, there is after all, in most of them, a considerable range of proportion outside the dolomitic limit, and the mean given of all the analyses shows that, in most cases, the magnesian carbonate cannot have been present to an extent of more than 14 or 15 per cent., and that in all, it is much less than the lime carbonate—thus completely verifying my experiments, and showing that those of Professor Rogers are not based on natural processes.†

I think, on the whole, it might be safely asserted that in every case where atmospheric water acts on a limestone rock, it will remove proportionately more carbonate of lime than carbonate of magnesia. The reason for this it would be difficult to give, seeing that there can be no doubt as to the somewhat greater solubility of magnesian salts under *laboratory* conditions.

If we suppose, however, that the carbonate of magnesia, in whatever proportion it is present in the rock, is originally combined *as dolomite*, it might account for what otherwise appears to be an anomaly. Is there any difficulty in supposing that the small amount of magnesian carbonate which it is known many corals and molluscan shells contain, sometimes reaching as much as 7·6 per cent. may have been secreted as dolomite?

Forchammer has shown that some corals, annelids, and molluscan shells, contain an appreciable quantity of carbonate of magnesia; in the annelidæ especially it being very high (7·6 per cent.) Bischof, commenting on this fact, remarks, the limestones formed by *serpulæ*, *corallium*, *isis*, and probably other genera, ought to be termed dolomitic limestone.‡

It is possible that many other organisms, such as build up rocks, secrete carbonate of magnesia to a perceptible amount. Many plants also secrete carbonate of magnesia, and it is just possible that in such cases the carbonate of lime and of magnesia may be combined as dolomite. In such an event the removal of the excess of carbonate of lime, which might in these instances be regarded as a matrix, would soon result in a dolomite.

It cannot be said that the foregoing analyses of waters prove much with regard to the relative solubility of the carbonates, since we have

* See Bischof, *op. cit.* iii., pp. 162, 196, 200, 203, &c. Bischof does not, however, entirely favour this theory, which is Grandjean's, not his own, but allows merely that such a process is possible in some cases.

† Bischof asserts that even springs rising in dolomite must always contain more carbonate of lime than of magnesia, as, from his experiments, carbonated water extracts little or no carbonate of magnesia from dolomitic rocks—*op. cit.*, vol. i., p. 81.

‡ Bischof, *op. cit.*, vol. i., p. 183; vol. ii., pp. 48, 49.

in few instances any information as to the composition of the rocks over or through which they passed; and these rocks may have contained but a trace of magnesia. But we can assert this much; that on the generally received notion as to the relative solvency of those bodies, and with which, save in the event of their being combined in rocks—when it certainly seems to reverse its behaviour—I must coincide, the result of such waters percolating through rocks would be, if anything, to form limestone, and not dolomite, since the carbonate of lime being more abundant, as well as less soluble than the carbonate of magnesia, would be more likely to be deposited. In all these supposed infiltration theories too, the bulk of the rock would necessarily be increased, unless it is taken for granted that some of the carbonate of lime is removed in the process, and replaced by carbonate of magnesia.

The only way in which the production of at least the Irish dolomites can be accounted for is, by the gradual removal of the excess of carbonate of lime. It is quite possible, and indeed likely, that in such a process, as the solution contains some carbonate of magnesia, a part of it in the form of dolomite may be deposited in a different part of the rock from which it was derived; the waste of one portion going to help to build up another.*

One point in favour of the abstraction theory is, that the Irish dolomites are exceedingly porous, cellular, or cavernous. Another curious point is that the cavities are almost invariably filled with calcspar; and not bitter spar or dolomite, as is generally stated. I have carefully examined the dolomitic limestones which occur so plentifully in the Counties Carlow and Kilkenny, and are spread over a large area, as well as some in the Counties Waterford, and Tyrone; and I can safely say that in no case have I found specimens of dolomite or magnesite in the cavities, but, on the contrary, calcspar most abundantly.

At Drumreagh, near Coal Island, Co. Tyrone, several beds of dolomite are interbedded with the ordinary blue fossiliferous limestone, and one of the beds merges gradually into the limestone, showing conclusively that it is metamorphosed limestone, and not the result of original chemical deposition on the sea bottom, according to Dr. Sterry Hunt's theory of such rocks. It is a light brown, extremely hard, crystalline, but compact dolomite; but so very cavernous that it is most difficult to obtain a fracture of it showing the true structure. The cavities are often large, as much as a foot in diameter, and coated, or often entirely filled, with nearly pure calcite, which may be obtained in large, nearly transparent rhombohedrons. The dolomite is perfectly unaffected by acid, in the cold. I should say that fully half the original rock is wanting, being now only represented by the spar-coated cavities.

* I think Bischof makes a similar suggestion.

It is perfectly clear that these cavities were produced by the action of water, no doubt acting on the more calcareous parts of the rock, which of course would not be homogeneous in composition. Such a removal of the lime in one part might be accompanied nearly simultaneously by the deposition in a previously formed cavity of some of the material brought away. The calcareous water trickling down the sides of such a vacancy would have a good opportunity of evaporating, and depositing its freight. It is possible in such cases both the percolation and the evaporation of the water would be slower, and more uniform than in large caverns; and thus largely crystalline masses of calcite would result, instead of finely crystalline stalactites.

This cellular character of dolomitic limestone is exceedingly well shown in a quarry at Loughry, near Cookstown, County Tyrone, in which is the following section:—

Section at Rockhead, near Loughry.

	Feet.	Inches.
3. Boulder clay, ...	5	0
2. Purplish crystalline encrinital limestone passing downwards into purple dolomitic limestone, with large cavities,	3	10
1. Sandstones and grits, ...	7	1
	15	11

The upper beds, which are dolomitic, are eaten away in curious cavities, as shown in the sketch (fig. 1, Plate 41). These were possibly formed during the alteration of the limestone. They could hardly have occurred since, because dolomite once formed is so insoluble. The cavities also are coated with calcspar.

In the south-east of Ireland the carboniferous limestone is much dolomitised, and affords good opportunities for the study of that mineral. In some places, as in the county Carlow, a persistent band of black dolomite extends for miles, as may be seen on glancing at the Carlow Sheet of the Geological Survey Map.* Here it occupies such a definite position in the carboniferous series, that it might be taken to be an important division of it. The rock, where perfect, is hard, compact, and sub-crystalline, but it is wonderfully cellular, fully a third of it being wanting. The cavities are, so far as I can judge, coated only with calcspar. After many searches I was unable to find a single specimen of bitter spar, or dolomite, which can only occur here in a very few isolated localities, if at all.

Professor Jukes made a certain distinction between varieties of the

* Sheet 137.

dolomites of the south of Ireland, *i. e.*, dolomites of original deposition, and dolomites produced by alteration of the original rock, with the former of which the Carlow rock appears to have been classed, while that of Kilkenny is supposed to be metamorphic. I rather think, however, that they both are metamorphic, only in different degrees.

The Kilkenny magnesian limestones are true dolomites both in appearance and composition. They contain from 30 to 44 per cent. of carbonate of magnesia; they are usually very crystalline, of a light yellow to a pearly grey colour, and do not effervesce when treated with acid, except occasionally in the interstices between the crystals, owing to infiltrated carbonate of lime. They are remarkable for the same cellular or cavernous structure which I have noticed in all the other dolomites of Ireland; the vacancies being coated, or filled entirely with calcspar. In some places the material has been removed in an exceedingly curious manner, the vacant spaces running parallel to each other, and forming apparently lines of bedding, which, however, they are not, as the true bedding is often also visible in such instances. Sometimes they give the similitude of false or current bedding, as is shown in the sketch (fig. 3, Plate 41).

As a rule, the bedding *is* obliterated, and in weathering the rock assumes at the surface of the ground, or wheresoever else exposed, a ruggedly pointed aspect, as if dipping vertically, along the lines of joints; and this often gives rise to picturesque hillocks or escarpments; the dolomite remaining, while the more easily dissolved limestone is eaten away to a lower and more uniform level, contrary to the general idea which assumes that dolomite is more soluble than limestone, because under certain influences it disintegrates more rapidly.*

Near the city of Kilkenny very extensive masses of dolomite occur, which could only have been formed by the metamorphism of the original limestone; and in one locality—Riverview, 1½ miles west of the town—there is a very fair opportunity of studying the mode of its production. And it will be seen that this can be reasonably explained

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* A well-known instance of this is shown by the decay of the stones used in the present Houses of Parliament, being magnesian limestones from the Mansfield Woodhouse quarries, and from Anston, Yorkshire. (See Building and Ornamental Stones, Prof. Hull, p. 200.) Under the influence of the vitiated atmosphere of London, some of this stone soon commenced to crumble away. It must be remembered that the disintegration of dolomite is not due always to the dissolution of the whole rock, but is most often merely the result of the solution of the carbonate of lime, which cements the crystals of true dolomite together. Any one who has observed the process of weathering of dolomites will remember that the minute crystals of which the rock is composed merely fall away from each other, resulting in a loose sand-like mass, but they do not readily decompose.

According to Ansted, the most durable magnesian limestones, for building purposes, are those containing nearly equal parts of carbonate of lime and of magnesia *in a state of perfect combination*—that is, true dolomite.—See Ansted's Geological Science (Orr's Circle of the Sciences), p. 208.

on the theory put forward already, that is, the extraction of carbonate of lime from the limestone rock.

A small stream runs from the railway down to the Nore at this place. On one side of it, to the south, dolomite crops out, with its usual rugged aspect. On the other side, blue fossiliferous limestone. At first sight it would seem that the limestone ended abruptly against the dolomite, but in reality it dips underneath it. The dolomite presents the usual characteristics, being highly crystalline, and full of drusy cavities, with calcite. The limestone is a compact bluish rock, in thick beds; the upper beds are magnesian, although not yet dolomitic, but they are beginning to show the drusy cavities, and are undoubtedly some distance on their way in the direction of dolomite. The most interesting fact, however, is, that between every individual bed of the limestone is a thick layer, or rather bed of calcite, from three to nine inches thick; and this is even visible on the top of the uppermost bed, which there is overlaid by a thin coating of drift clay or soil; but eventually disappears under the dolomite. (See fig. 2, Plate 41.)

Now it is perfectly evident that the calcite layers are derived from the limestone beds above them. It would be difficult to prove that each layer was derived solely from the immediate bed above it, but this is not impossible. The calcites are of a fairly uniform thickness, and the quantity abstracted from the overlying beds would be quite sufficient to alter very materially the composition of the limestone. These beds are about eighteen inches thick, and the corresponding calcites three to nine inches. Taking the latter, and assuming, for argument sake, that the limestone originally contained about 12 per cent. of carbonate of magnesia, the removal of sufficient calcite to form a layer nine inches thick would increase the percentage of magnesia carbonate in the limestone to over 20 per cent., which would nearly correspond to the composition of some dolemites.

One other point with regard to the Irish dolomites I have already partly referred to—viz., that they help to supply further evidence in refutation of Dr. Hunt's theory as to the origin of dolomitic rocks, that is, their original deposition as sediments from an evaporating sea basin, and subsequent modification by heat. I cannot do better than here quote more fully Dr. Hunt's words. (See "Conclusions" of his paper on the Chemistry of Dolomites and Gypsums.*) "Dolomites, magnesites, and magnesian marls, have had their origin in sediments of magnesian carbonate, formed by the evaporation of solutions of bicarbonate of magnesia. These solutions have been produced either by the action of bicarbonate of lime upon solutions of sulphate of magnesia, in which case gypsum is a subsidiary product, or by the decomposition of solutions of sulphate or chloride of magnesium by the waters of rivers or springs containing bicarbonate of soda. *The subsequent action of heat upon such magnesian sediments, either alone or*

* Chem. & Geol. Essays, p. 90.

mingled with carbonate of lime, has changed them into magnesite or dolomite." I cannot see that this theory differs in any essential respect from that of Von Morlot (see *ante*, p. 705), which Hunt himself condemns; but it altogether fails to account for what frequently occurs near Kilkenny.

(1). The dolomites are often interstratified with ordinary blue limestone highly fossiliferous. The section at Riverview is one out of many that shows this. On the evaporation theory we should suppose a most extraordinary series of oscillatory movements, alternating between a deep and clear sea, fitted to sustain the life of corals and such organisms, and again a land-locked lagoon merging into a salt lake: all this repeated many times, in the process of producing a few hundred feet of the interstratified rocks. This is, I venture to say, inconceivable. In order to get a deposit of carbonate of lime alone, at least three-fourths of the sea water must be evaporated, as Bischof has shown;* but even then the carbonate of magnesia will remain in solution a considerable time longer. By the time the water became sufficiently dissipated for the latter to subside, the sea would have become a veritable pickle in which few organic forms could live.† Yet we have highly fossiliferous dolomites, which would prove that the animals lived in the sea water during the time of the deposition of those rocks, and that, during a very considerable time besides. In fact, on the evaporation theory we should have only the following distinct groups:—(1), carbonate of lime; (2), magnesite; (3), gypsum; (4), common salt; but no dolomite. It is quite possible, however, that some dolomites, such as those of the Permian formation, may have been indirectly the result of evaporation; thus, that during the process of concentration a greater amount of carbonate of magnesia might be assimilated by the animals then living in the lagoon; and thus that the alteration to dolomite might be sooner effected afterwards. It seems to me that it is only by this assimilation, and the subsequent removal of the excess of carbonate of lime, that large masses of dolomite could be formed; for if we consider the very small percentage of carbonate of magnesia or lime present in sea water, and suppose even a portion of it enclosed in a position favourable to evaporation, it is clear that the beds of sulphate of lime, and of the chlorides, would bear an enormous proportion to those of carbonate of magnesia or lime, or to dolomites.

(2). Again; were the dolomites originally deposited chemically, they should form perfectly definite beds—dolomite, and nothing else. It would be perfectly impossible, under any circumstances of evaporation, to have the same bed at one place limestone highly fossiliferous, and at another (a few yards off) truly dolomitic, the fossils

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* Chem. Geol., i., p. 177.

† Except perhaps those remarkable salmon which, as related by Smollett, in "Humphrey Clinker," the Scottish laird kept in a tank, to which he gradually added more and more salt, &c.; so that at last they could be taken alive ready pickled!

altogether obliterated. But this is a constant occurrence among Irish dolomites.* I have already referred to one instance of it in the Co. Tyrone; it is also frequent in the County Kilkenny, in many places within a circle extending from Gowran to near Ballyragget; and I have hand specimens showing the gradual alteration, the fossils being completely obliterated, and the blue limestone at one side becoming perfect crystalline dolomite at the other. Large masses of dolomite are seen, which, when traced out, are found to abut against and merge into limestone, and in some places, as at Ballyfoyle, there will be as many as twenty or more alternations of limestone and dolomite in a distance of less than half a mile; the limestone always full of marine fossils, by no means dwarfed in appearance. (See figs. 4, 5, 6, Plate 42).

[*Note added in Press.*—I have mentioned that limestones are by no means homogeneous in composition, and that the cellular structure would be capriciously determined by the most calcareous, and therefore most soluble parts. I have lately analysed some limestones from Ballyfoyle, which are interlarded with and pass into dolomite. The following were made from specimens of the same bed, taken a few yards apart:—

ANALYSIS OF LIMESTONE FROM BALLYFOYLE.

	I.	II.
Carbonate of lime, . .	87·72	91·06
,, ,, magnesia, .	3·80	1·00
Ferric oxide and alumina,	2·52	2·05
Insoluble residue, . . .	5·80	5·70
	99·84	99·81

SPECIFIC GRAVITY, 2·89.

Specific Gravity of Dolomite.—On the principle I have advocated, viz., the removal of carbonate of lime from limestones, and the consequent porosity of the resulting dolomite, the specific gravity ought to be less than that of limestones. I am aware that Dr. Apjohn has, in the paper already cited, stated the contrary; but it must be remembered that the determination is rendered very difficult in the case of dolomite by the circumstance that, while in the mass, it is porous and cellular, and *must* be of less specific gravity than limestones, which are compact—the small pieces, which could only be weighed on our balances, are usually compact. However, those I have tried certainly possess a lower specific gravity than limestone. This is shown in the examples given above of the Ballyfoyle dolomite and limestone.]

* Bischof refers also to this fact as common to dolomitic formations.

Crystallization.—The very distinct crystalline appearance of dolomite is a matter requiring important consideration, but it is in truth one of the chief difficulties of the whole question. From whatever stand-point we approach the subject, and whatever the theory which we adopt may be, this is not very easy to account for. The infiltration of carbonate of magnesia could hardly of itself afford this peculiar structure, for it would only give a perimorph, or at least a pseudomorph, of magnesite, by replacing part of the carbonate of lime in the calcite. But even magnesite after calcite is not frequent. Blum and others refer to it as occasionally occurring in lodes, and in geodic cavities; but it is not likely often to be discovered, for Bischof found it impossible to effect any decomposition between carbonate of lime, and a solution of bicarbonate of magnesia.*

On the other hand, all limestones, with the exception of the earthy varieties, are more or less crystalline, and the crystals of calcite differ only to a very slight amount from those of dolomite—so little that the principal angle of the rhombohedron of calcite being 105°5′, that of dolomite is 106°15′, a difference quite inappreciable, without the aid of delicate instruments. This being so, if a quantity of superabundant carbonate of lime be removed from a highly magnesian limestone, such as would, according to Bischof, be formed by the agency of certain organisms, the crystalline structure would appear very distinctly, even in magnesian limestones that were still far removed from dolomites. In fact in few dolomites are the crystals really distinct until the rock has begun to decompose, and I could point out many localities near Kilkenny where true dolomites are perfectly compact, to all appearance, where unweathered, but once attacked by the atmosphere show themselves to be highly crystalline; the process being just what I have suggested above, viz., the removal of the superfluous carbonate of lime. This is, however, an extremely difficult province of the question to enter upon, and an opinion on it is not to be advanced without great diffidence, during the existing state of our information about it.

Conclusions.—(1). It appears, therefore, that the Irish carboniferous dolomites could not have been completely originated by organic agency, nor could they have been formed by chemical deposition due to evaporation of sea water; and there seems to be evidence of few other dolomites being formed in the latter way.

(2). The experiments recorded in the preceding paper, showing the much greater solubility of carbonate of lime than of carbonate of magnesia, from rocks treated with a carbonic acid solution, appear to bear out the theory that dolomite may be formed by the extraction—by water holding in solution small quantities of carbonic acid—of the excess of carbonate of lime from magnesian limestone rocks.

In this way, also, it is easy to account for the fissures and cavities

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* See Note to p. 708.

so common to dolomites, and the filling up or coating of these cavities with carbonate of lime.

The frequent occurrence of quantities of carbonate of zinc in dolomites may also be explained thus : the concentration, simultaneously, of the carbonates of zinc and of magnesia being accomplished by the removal of the carbonate of lime.* The resulting dolomite being then less soluble that the carbonate of zinc, the latter would be dissolved out and again deposited alone in the lower cavities of the rock.

On the other hand, the percolation of water containing carbonate of magnesia would add to the bulk of the mass, unless something was abstracted in place of the carbonate of magnesia deposited. This could only be carbonate of lime, but Bischof's experiment is against that. Besides, as water usually contains about ten times as much carbonate of lime as of magnesia, were any deposition to take place, the lime would certainly be deposited before the magnesia, and would not only increase the bulk, but neutralise the dolomitization.

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* I have already pointed out that zinc is nearly always associated with, or an accessory of, magnesian minerals. *Vide* On the supposed Substitution of Zinc for Magnesium in Minerals, Proc. Roy. Ir. Acad., 1874.

LVI.—REPORTS FROM THE CHEMICAL LABORATORY OF TRINITY COLLEGE, DUBLIN. By J. EMERSON REYNOLDS, M. D., M. R. I. A., Professor of Chemistry, University of Dublin.

No. 1.—ON GLUCINUM: ITS ATOMIC WEIGHT AND SPECIFIC HEAT.

[Read April 10, 1876.]

AMONGST the few rare elements found in Ireland is the metal Glucinum or Beryllium, which occurs in the well-known alumino-glucinic silicate, beryl or "emerald;" this mineral is found in comparative abundance, though in a rough state, in the granites of Donegal, and is somewhat less freely distributed through the granites of the Mourne Mountains in the county of Down. As the "atomic weight" of glucinum has not yet been definitely fixed by the determination of the specific heat of the metal, it seemed desirable that we in Ireland should make the necessary crucial experiments. Hence, about seven years ago, I commenced to collect the crude Irish beryls or "emeralds," and ultimately succeeded in obtaining 3 kilogrammes of the dressed mineral, from which I prepared nearly 350 grammes of the pure glucinic oxide.

I have to thank my friend Mr. William Harte, C. E., the excellent County Surveyor of Donegal, for the valuable assistance he kindly afforded me in collecting much of the mineral from which the glucinic oxide was prepared.

The satisfactory nature of the results of a set of preliminary experiments with the material at my disposal must be my apology for laying a short communication upon the subject before the Academy, at a very early stage of the investigation.

Some glucinic oxide was converted into the anhydrous chloride by the action of chlorine upon it at a full red heat in presence of finely divided carbon; and the metal was subsequently procured by the action of metallic sodium on the pure sublimed glucinic chloride. The reduction was effected by heating a suitable mixture in a platinum vessel, but the temperature was not allowed to rise sufficiently to liquefy the mass; and on removal of the material from the crucible those portions which had been in contact with the platinum were rejected. The resulting mixture of sodic chloride and reduced glucinum was then fused under common salt in a lime crucible; this precaution was taken in order to avoid contact with siliceous compounds. Considerable loss occurred in this operation; but I succeeded in obtaining a small coherent mass of metallic glucinum, which latter was found to agree in characters with the metal described by Debray,* though

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* *Annales de Chimie et de Physique*: troisième série, tom. xliv., p. 5 (1855).

that distinguished chemist effected the reduction of his metal in a different manner.

If we admit with Awdejew, and with Debray, the number 4·6 to be the equivalent of glucinum (H = 1), the question remains whether the "atomic weight," so called, is a multiple of the equivalent by 2 or 3.

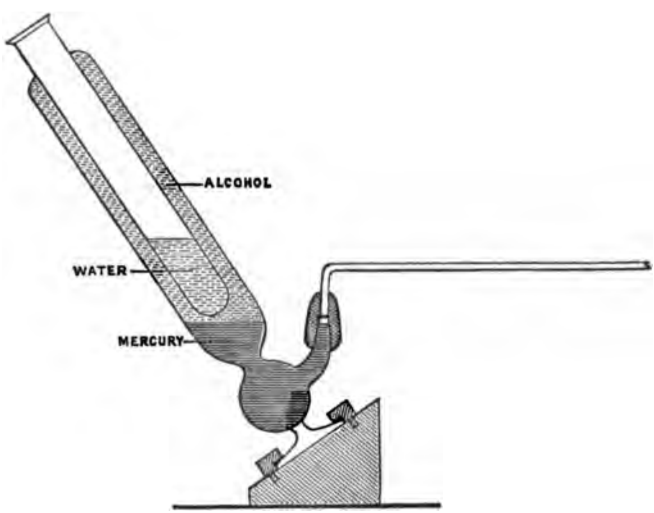
If, as some assert, the "atomic weight" is 4·6 × 3 = 13·8, the only known oxide of glucinum must resemble alumina. If, on the other hand, the atomic weight is 4·6 × 2 = 9·2, glucina must be an oxide like that of zinc or of magnesium. Each view has received the support of a group of chemists of the highest eminence, but owing to peculiar difficulties surrounding the case, an appeal to chemical criteria has hitherto been insufficient to decide between the two conflicting opinions—a determination of the specific heat of the metal, or of the vapour density of one of its compounds of simple constitution, being necessary for the final settlement of the question. Of these methods I chose the former, and, having made several determinations of the capacity for heat of metallic glucinum, I have the gratification to state that the data obtained lead to the conclusion that the atomic weight of glucinum is double the equivalent weight. Glucinum is, therefore, a diatomic metal with an atomic weight of 9·2; though, I may add, this number may be slightly affected by a new determination of the equivalent in which I am engaged.

The method pursued in making the necessary determinations upon which to found the conclusion just stated was devised for the purpose of this inquiry; and as it is essentially different from any with which I am acquainted, I may be permitted to indicate very briefly the plan adopted after a good deal of preliminary investigation.*

The well-known law of Dulong and Petit, as modified by Cannizzaro, asserts that the atoms of elementary matter have the same capacity for heat, when we compare them in the solid state. The outstanding exceptions to this important law are few, and even these appear to have been cleared away in some degree by the recent researches of Weber on the specific heats of silicon, boron, and carbon. The principle, however, is admittedly sufficiently general in its appli-

* The preparation of pure metallic glucinum in quantities exceeding two or three grammes is difficult and costly; for this amongst other reasons, I determined to employ Bunsen's admirable and theoretically perfect ice calorimeter in the estimation of the specific heat of the metal, as small quantities of material only are required. It proved, however, to be impossible, owing to various engagements, to prepare the glucinum in a state of sufficient purity until the season had passed when Bunsen's ice calorimeter can be conveniently used. I had, therefore, to devise a calorimetric method which could be employed during warm weather, and which could afford trustworthy results with small weights of material. I have given in the text an outline of this method, but the details of its application to the determination of atomic and molecular heat will form the subject of another communication.

cation to enable us to found upon it a plan for the determination of the atomic weight so called of a particular element: for it is evident that if we employ as a standard a metal whose atomic weight and specific heat are both accurately known—silver for example (= 108)—the weight of another solid element which contains the same quantity of heat at 100° C. as 108 parts of pure silver at 100° C. is the atomic weight of the element. In seeking to compare glucinum with pure metallic silver in this way, I succeeded in arranging an experimental method which not only enabled me to attain the object I had in view, but also to demonstrate the truth of the law just referred to. The apparatus required is easily constructed, and consists of a spirit thermometer with a cylindrical "bulb" in which a test tube is sealed after the manner of Bunsen's ice calorimeter. This part of the apparatus is easily constructed from a small chloride of calcium drying tower as shown in the diagram. Although the larger "bulb" of the thermometer is filled with



spirit, the lower one and the stem are full of mercury, and connected with a fine capillary tube carefully graduated in millimetres, and calibrated. The arrangement constitutes an exceedingly delicate spirit thermometer, with a mercury index.

When it is desired to compare a solid element with silver, in order to fix the atomic weight, it is necessary to make a preliminary experiment with the standard metal. For this purpose one cubic centimetre of distilled water is placed in the test tube which is immersed in the bulb of the thermometer, and when the temperature has been equalised, and the thread of mercury has reached a suitable position in the stem, a piece of pure silver weighing 108 centigrammes, and heated to 100° C. in steam, is rapidly dropped into the cubic centimetre of water, and the expansion caused in a given time carefully noted.* According to the law above stated, a centigramme atom, if I may use the term, of any other metal than silver ought to cause exactly the same expansion, when the experiment is made with it under precisely the same conditions; and these conditions are very easily realised. I have ascertained that such is the case, and the approximate equality in "atomic heat" of many of the metals has thus been easily demonstrated.

The comparison of glucinum with silver was made on this plan, and it was found that the weight of glucinum which contains nearly the same quantity of heat at 100° C. as 108 centigrammes of silver at the same temperature, is not 4·6 or 4·6 × 3, but 4·6 × 2, or 9·2 centigrammes.

The "atomic heat" of silver, or the product of the specific heat (= ·05701 according to Regnault), into the atomic weight (= 108) is 6·157. Using this number as the standard for reference, the experimental number found for the atomic heat of the specimen of glucinum operated with is 5·91. Thus:—

Atomic heat of silver = 6·157
Atomic heat of glucinum = 5·910

The difference is less than the known difference between the atomic heat of silver and that of aluminium; but I am inclined to think that the lower number found for the glucinum used is due to the presence of a trace of platinum in the specimen of metal. Owing to the high atomic weight of platinum (= 197·1), as compared with that of glucinum (9·2), the presence of even a small quantity of the former metal must very sensibly affect the determination of the atomic heat of glucinum. I hope soon to be in a position to continue these experiments with the *pure* metal.

It will, however, appear from the following considerations that we may fairly regard the above determination of the atomic heat of glucinum as being of such value as to enable us, even at an early stage of the inquiry, to use it as a physical control, and to fix the atomic weight of the metal, subject of course to the probably small change in the numerical expression which may prove to be necessary as the investigation proceeds.

If we assume the atomic weight of glucinum to be 9·2 and employ the value I have obtained for the atomic heat, *i. e.*, 5·91, we can calculate the specific heat of the metal by means of the formula.

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* The apparatus is carefully protected from the influence of air currents during the experiment.

$$S = \frac{H}{A}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

when S represents the specific heat, H the atomic heat, and A the atomic weight of an element. The specific heat of glucinum thus calculated is ·642.

If now we substitute for H a constant, which in this case is the product of the well-ascertained atomic weight of silver* into its equally well determined specific heat, A S = 6·157, the expression becomes

$$S = \frac{6 \cdot 157}{A}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and with its aid we can calculate the specific heat of any solid element, if its atomic weight is known or assumed. I have thus calculated the specific heat of glucinum on the assumption (*a*) that its atomic weight is 9·2; (*b*) that its atomic weight is 4·6, and (*c*) that it is 13·8.

The results are compared in the following Table with the specific heat obtained by calculation from the actual determination of the atomic heat of the metal:—

Specific heat of glucinum calculated (1) from the result of determination of atomic heat,

When A = 9·2, ... ·642.

Specific heat of glucinum calculated by (2),

When A = 9·2, ...	·669
When A = 4·6, ...	1·338
When A = 13·8, ...	·446

I am, therefore, justified in concluding that the atomic weight of glucinum is nearly if not exactly 9·2.

* We might obviously take any other product, but that of silver is here preferred because the atomic heat of that metal has been employed as the standard for reference.

LVII.—On the Chemical Changes which take place in the Potato during the Progress of the Disease. By the Rev. John H. Jellett, B.D., S.F.T.C.D.

[Read May 22, 1876.]

The object of the experiments described in this paper was two-fold, namely:—

1. To ascertain whether there be any development of sugar in the tuber, and if so, what is the kind of sugar developed.
2. To ascertain whether there be any perceptible change in the quantity of nitrogen.

The experiments were conducted as follows. Four specimens were taken from the same variety of potato, viz.:—

1. Perfectly sound potato.
2. Apparently sound part of potato in which the disease had just begun to appear.
3. Apparently sound part of potato in which the disease was far advanced.
4. Discoloured part of diseased potato.

These specimens, having been carefully weighed, were severally grated, then subjected to a strong pressure in a screw press, and finally exhausted with spirit.

The fluid so obtained was filtered, to remove the albumen and starch, and (the spirit having been distilled off) was diluted with water to a known bulk. It was then examined in the usual way for sugar. The result is given in the following Table.

Table I.

	I.	II.	III.	IV.
Water (percentage in tuber), . .	73·09	77·24	80·04	79·28
Nitrogen (do.)	·27	·35	·31	·25
Sucrose (do.)	·08	·29	1·14	·21
Glucose (do.)	·42	·65	·76	·40

For the second part of the experiment four specimens, selected as before, were carefully weighed and dried. They were then burned in the usual way, for the purpose of estimating the quantity of nitrogen. The results are given in the following Table.

TABLE II.

	I.	II.	III.	IV.
Nitrogen (percentage in dry residue),	1·00	1·53	1·55	1·26
Sucrose (do.) . .	·29	1·27	5·71	1·00
Glucose (do.) . .	1·59	2·85	3·81	1·93

The history of these chemical changes seems to be as follows:—

The first stage of the disease in the tuber is marked by an increase in the quantity of nitrogen.

This increase seems to have attained its greatest value before the appearance of any discoloration in the tuber.

The same stage of the disease is also marked by the development of sugar, both glucose and sucrose.

In the second stage, marked by a great increase in the discoloured part of the tuber, the part which remains apparently sound shows no increase of nitrogen but a very considerable increase in the quantity of sugar.

Finally, in the discoloured part of the tuber, there is a diminution both in the percentage of nitrogen and in the percentage of sugar.

Now it must be remembered, that in the vegetable kingdom the fungi contain the largest percentage of nitrogen, approaching nearly in this respect to the animal kingdom. A marked increase in the quantity of nitrogen would therefore seem to indicate a fungoid growth in the tuber. It would seem also that this growth attains a *maximum* value before the tuber shows any visible sign of disease.

The development of sugar appears to come somewhat later; at least it continues for a considerable time after the percentage of nitrogen has attained its *maximum* value. There can be, I suppose, no doubt that this sugar is formed by the conversion of the starch, which the potato contains in large quantity. If the sugar produced were wholly glucose, there would be no difficulty, as the presence of a small quantity of acid would be sufficient to account for the phenomenon. But I am not aware that there is any known method by which starch can be made to pass into sucrose. It is possible that this effect may be produced by the presence of the fungus, which is indicated by the increased quantity of nitrogen. I have not, however, succeeded in establishing experimentally the possibility of this conversion.

The appearance of discoloration marks the commencement of decomposition, and is attended, as we might naturally expect, by a diminution in the quantity both of nitrogen and of sugar.

LVIII.—Remarks on the Recent Discovery of Remains of the Cervus Megaceros at Ballybetagh. By George Porte, M. R. I. A.

[Read June 12, 1876.]

Many years ago I took great interest in the discovery of the remains of the Cervus Megaceros in various parts of Ireland, but during the recent explorations at Ballybetagh I had an opportunity of examining them *in situ*, under conditions differing so much from all that had previously come under my notice, that I think it desirable to place on record these unusual circumstances.

I am indebted to the courtesy of Mr. Moss for the opportunity of making my observations without any of the labour and trouble of superintending the excavations.

I have made the following notes as a supplement to his Report,* which could not be more accurate than it is, but it treats only of the mode of conducting the exploration, and the results obtained. I may observe that he is not in any way responsible for the opinions herein expressed; indeed, I have reason to think that he has not arrived at the same conclusions as I have on all points.

Judging from the dip of the sides of the valley where these remains were found, and comparing it with the excavations made, it appears that the central parts were originally some 15 feet below the present surface, and that a considerable stream or torrent ran through it. It also appears that at a very remote period this torrent was obstructed by some means or other, converting that part of the valley into a shallow lake or tarn, from an acre to an acre and a-half in area, and in no part more than about 15 feet deep; this tarn is now completely filled up with the usual lacustrine deposits (marl excepted), of which none appeared in the excavations made, although a considerable deposit of marl is found in a similar but larger basin, a couple of hundred yards lower down the valley.

Beneath the lacustrine deposits, lying on the bottom of the tarn, that is to say, on the original surface of the valley, the remains were found in immense quantities, firmly imbedded between the water-worn boulders which were thickly scattered over it.

In almost every county in Ireland similar remains have from time to time been found, and still a very common error prevails, even among well-informed people, that they are always found *in bogs:* this error originates in the custom of giving the general name of "bog" to every place where turf may be cut for fuel, whether it be a true peat-moss, or the basin of an extinct lake.

Now I have never been able to trace a single instance in which remains of the Cervus Megaceros were found in a real bog. So far as

* *Antea*, p. 547.

I am aware, they have hitherto, with one exception,* been found *only* in extinct lakes; and even in these they never occur in the vegetable mould forming the upper stratum or bog, but always in sedimentary marl, or blue clay, which underlies the bog; and when both these deposits exist in the same basin, the remains are generally found imbedded *in the marl*, and *resting on the blue clay:* the present being (so far as I am aware) the first instance of their being found resting on the bottom of the basin.

In the marl or in the blue clay they have been found at different depths in different basins, and sometimes even in the same basin, indicating that they were deposited at different periods during the formation of the stratum: and hence naturalists have been led to attribute the death of the animals to "miring" during their struggles with their predaceous enemies.

This hypothesis is probably in some instances correct, but it is difficult to reconcile it with the often observed fact of the wide dispersion of the bones, and still more with another well-known fact, namely—that heads and antlers are frequently found where no other parts of the skeleton can be discovered.

There is at first sight an apparent coincidence between the situation of these remains and that of most others previously discovered, but the coincidence is only apparent, while it is a real exception to the general rule. It is true that these have been found (as usual) in the basin of an extinct lake, but they have not been found *in* any lacustrine deposit, *but under them all*, in actual contact with the sandy clay which formed the original surface of the valley.

Furthermore, they presented to me the appearance of having been for a long time knocked about among stones, whereby they were much abraded and broken up before they got into still water; the detached parts have not in any case been found, so as to be identified. They also appeared to have been forced down between the boulders by some great vertical pressure, but not by the gradually increasing pressure resulting from the slow accumulation of lacustrine deposits. Moreover, the stratum lying immediately over them did not appear to me to be lacustrine at all, but more like the surrounding surface soil, and probably the result of a land-slip, or flood.

If the above views be correct, it appears almost certain that the remains were deposited where found, *before the lake or tarn was formed;* for had it existed even for a short time previously, *some sediment* would have been formed beneath the bones, but there was none.

In the next place *it excludes the possibility that the animals were "mired;"* had they been so, the remains would have been found *in* the lacustrine strata, and not entirely under them all, as above described;

* The exception above referred to is the discovery of a skeleton in drift sand (in 1828) above the Enniskerry river, which is separated from Ballybetagh by the Scalp range of hills.

and even if we suppose the mud of the lake to have been sufficiently fluid to permit the bones to sink through it, so as to rest on the bottom, they would touch it only at three or four points; the great mass of the antlers would stand up off the bottom; the sediment would form under and around them, and they would be found imbedded *in* lacustrine clay or marl; but they did not in any instance present such appearance.

It might be supposed that they were carried into the lake by the stream which flowed through it, and in fact their shattered and water-worn appearance has been thus accounted for, but they were entirely out of the course of the torrent, and in a part of the tarn near its margin that must have been still water from the first formation of the lake.

The conclusion at which I have arrived on this part of the subject is, that the remains were deposited where found *all at once*, and *before the lake was formed.*

But even though the bones might be deposited *all at once* where they were found, it does not necessarily follow that the herd perished all at once by any sudden catastrophe. The remains might have been accumulating for many years; but if such were the case, it is hardly conceivable that there should not be found among them the remains of even one female. Of the six-and-thirty heads exhumed *all* were males. I think this one fact negatives the possibility of the accumulation extending over many years; it is more probably the result of the final extinction of the vast herd of these noble animals that once roamed over those hills.

The absence of female remains has been accounted for by the supposition that the herd perished by some sudden disease or catastrophe during the season of the year when the males and females herded separately, which may be roughly stated as from April to October. I think the suggestion very reasonable, and, if true, the remains of the females are to be found in equal quantities at no great distance from the former, probably on the other side of the tarn.

Had they perished while the two sexes intermingled, *i. e.*, from October to March or April, we might reasonably expect to find their remains mixed in due proportions; it seems to me therefore almost certain *that they did not perish during the winter months.*

I think it possible, by a similar method of exclusion, to fix the season at which they perished with reasonable probability: *e. g.*, among the six-and-thirty heads exhumed, not one was destitute of antlers; that is to say, not one of the animals perished during the season between the fall of the antlers and their reproduction, embracing May and the first half of June; not one during the early stages of growth, including the remainder of June and July. It would not be possible without microscopical examination to assert that none of the antlers found were in *any* stage of growth; but I hope during this summer to make such investigation as will decide this question.

When the antlers were fully grown, the males and females mingled together again, and the rutting season commenced.

Some of the remains present the clearest possible evidence that the animals perished *during the fall of the antlers;* that is to say, during the latter part of April, and part of May; the burr and constriction around the base of the antler marking the preparation for its fall being in various stages of progress, from the first enlargement of the burr; almost to a perfect constriction: *no doubt therefore can exist as to the season of the year at which they perished.*

Of those not thus marked, no certain evidence of time exists, except that the antlers were fully developed at the time of death: I think it, however, extremely probable that all perished *at the same time.*

I may observe here, once for all, that in speaking of months and seasons, I have assumed that these were somewhat like what they are at present; and also, that the habits of the great deer did not differ very much from those of existing species.

Among the remains are three or four shed antlers, but the skulls to which they belonged were not found, unless we assume them to be castings of preceding years.

It is worthy of remark that the find consisted almost entirely of heads and antlers. All the other bones found with the thirty-six heads and antlers would not be sufficient to build up a single skeleton; but it is extremely probable that the smaller bones would be found in similar quantities in the central parts of the valley answering to the deeper parts of the ancient tarn, *i. e.*, assuming the remains to have been brought there by the agency of water.

There is apparently no limit to the quantity of these bones that might be obtained if necessary, but I do not see that any useful end could be answered by exhuming cartloads of similar remains, and in the same condition; but I think that some additional knowledge of this noble animal might be obtained by exploring the opposite margin of the valley, and also the middle or deeper parts, in order if possible to discover what has become of the herd of females, which we may assume did not differ very much in number from the males.

On the whole, I do not think the evidence at present before us would enable us to decide where or by what means this magnificent herd became extinct, though we may be able to say with reasonable certainty *where* and *how* they did not perish.

Were I disposed to theorise, I might answer these questions with reasonable probability, but I prefer laying before the Academy what I consider *proved facts,* in order to have them placed on record for the aid of future explorers in this field of science.

LIX.—The Detection and Precipitation of Phosphoric Acid by Ammonic Molybdate. By Archibald Nichol M'Alpine, B. Sc. (Lond.), Royal Exhibitioner, Royal College of Science.

[Read June 26, 1876.]

The detection and precipitation of phosphoric acid by ammonic molybdate has occupied the attention of several chemists.

Richters* has found that the test is rendered more delicate, and precipitation more rapid, if ammonic nitrate is added to the solution to be examined for the phosphoric acid prior to adding the molybdic test.

From a series of experiments I have made, I find that the test can be rendered still more delicate, and the precipitation still more rapid, if an *excess* of ammonic molybdate, some strong nitric acid, and finally, strong ammonia, be added to the solution, until it is nearly *neutral*. In this way I found phosphoric acid in waters which yielded no trace with the usual molybdic solution after standing at a gentle heat for a considerable time.

In making my experiments I noticed that molybdic acid is easily separated from the larger portions of the ammonia with which it is combined, under certain conditions; these conditions are that the solution should be hot, and saturated with ammonic nitrate, and that free nitric acid should not be present in excess. It may be that the greater delicacy of the test, in a phosphate solution containing nitric acid to which ammonia has been added to near the neutral point, is due to the formation of this acid molybdate, which combines with the phosphoric acid to form the ammonio-phospho-molybdate precipitate.

I then made some experiments to determine the effect of nitric acid on the precipitation. I found that beyond a certain point nitric acid hindered the precipitation in very dilute phosphate solution, and generally it retarded the formation of the precipitate. This is contrary to the statement made in some of the works on chemical analysis.

To determine good proportions for the ammonia and nitric acid, I made various experiments with 10 cubic centimetre portions of a phosphate solution containing ·010 grammes of phosphoric acid per litre, varying the quantities of nitric acid in the different experiments. I added ammonia to the solution until the precipitate formed most favourably, and finally I determined the amount of free acid remaining in the solution. I found the following proportions made the test the most sensitive:—

* See Dingl. Polyt., J. cxcix. 183; also vol. 24 Chem. Soc. Journal.

60 grammes Ammonic Molybdate.
500 cc. Nitric Acid (sp. gr. 1·4).
400 cc. Ammonia (sp. gr. ·96).
400 cc. Water.

A solution containing these proportions gives an immediate precipitate if added to 10 cubic centimetres of a phosphate solution containing ·01 grammes of phosphoric acid per litre.

I next tried the effect of hydrochloric acid on the precipitation. For this purpose I employed 10 cubic centimetres of a solution containing ·01 grammes of phosphoric acid per litre, 3 cubic centimetres of the ordinary laboratory solution of ammonic molybdate, and 2 cubic centimetres of strong hydrochloric acid. There was no precipitate after shaking and allowing to stand for some time, but on adding ammonia a precipitate was produced which was not so rapid in its formation, nor so copious as when nitric acid was present.

I now tried to obtain a volumetric test for phosphoric acid. To avoid the necessity of adding excess of ammonic molybdate, I added to the solution sodic molybdate, which does not precipitate the phosphoric acid, and then ammonic molybdate. For example, I took 50 cubic centimetres of a solution of phosphate of soda containing excess of sodic molybdate. 5cc. of ammonic molybdate appeared to precipitate the phosphoric acid completely, as the further addition of ammonic molybdate to a portion of the filtered solution gave no precipitate on heating, nor the reaction for ammonic molybdate on adding phosphate solution. Thus it appears that by using an excess of sodic molybdate, the necessity for an excess of ammonic molybdate is avoided. I made various other experiments in this way, and it seems as if there was a point at which the precipitation of the phosphoric acid is complete, and no ammonic molybdate in solution.

Lastly I substituted for the ammonic molybdate ammonic nitrate, which I added to the phosphate solution containing excess of sodic molybdate, and here also there appeared to be a point where the precipitation of the phosphoric acid was complete, and no ammonia in solution.

I now attempted to determine the point of complete precipitation in various ways, but I could find no convenient way of determining the exact point, when all the ammonia as well as the phosphoric acid had been precipitated.

LX.—On a Certain Relation between the Quadratic Expression $Q^2 - 3PP'$, and the Product of the Squares of the Differences of the Roots of a Cubic Equation. By J. R. Young, formerly Professor of Mathematics in Belfast College.

[Read June 26, 1876.]

Let
$$x^3 + px + q = 0 \tag{1}$$
be the equation which results from depriving the cubic equation,
$$x^3 + A_2x^2 + A_1x + A_0 = 0 \tag{2}$$
of its second term; that is, let (1) be the equation which arises from diminishing each of the roots of (2) by $-\frac{1}{3}A_2$; then, conformably to the notation of my former Papers,

$$P = x^3 + px + q$$
$$Q = 3x^2 + p \qquad \therefore\ Q^2 = 9x^4 + 6px^2 + p^2$$
$$P' = 3x \qquad 3PP' = 9x^4 + 9px^2 + 9qx$$
$$\therefore\ Q^2 - 3PP' = -3px^2 - 9qx + p^2.$$

Now, the square of the middle co-efficient of this quadratic expression, diminished by four times the product of the extreme co-efficients, furnishes the

$$\text{Remainder, } 81q^2 + 12p^3 = 3(27q^2 + 4p^3);$$

which (with changed sign) is three times the product of the squares of the differences of the roots of the equation (1). (*Theory and Solution of Equations*, p. 410). [This is proved independently at the end].

But the differences of the roots of the equation (2) are the same as the differences of the roots of the equation (1); because the roots of (2) are no other than the roots of (1), each increased by the same quantity; namely, by the quantity $-\frac{1}{3}A_2$.

Calling this quantity a, the equation (2) is
$$(x + a)^3 + p(x + a) + q = 0;$$
and the expression $Q^2 - 3PP'$, for *this* equation, is
$$Q^2 - 3PP' = -3p(x + a)^2 - 9q(x + a) + p^2$$
$$= -3px^3 - (6pa + 9q)x - 3pa^2 - 9qa + p^2.$$

The square of the middle co-efficient here is

$$36p^2a^2 + 108pqa + 81q^2$$

and 4 × the prod. of the extremes, $36p^2a^2 + 108pqa - 12p^3$

$\therefore$ the remainder is $81q^2 + 12p^3$,

which, as might have been anticipated, is the same as the remainder above; and the remainder would still be the same whatever be a. If we represent the expression $Q^2 - 3PP'$ by $Ax^2 + Bx + C$, and the roots of the equation

$$Ax^2 + Bx + C = 0$$

by r_1 and r_2, then will

$$\frac{B^2}{A^2} - 4\frac{C}{A} = (r_1 + r_2)^2 - 4r_1 r_2 = (r_1 - r_2)^2;$$

and therefore,

$$B^2 - 4AC = A^2(r_1 - r_2)^2. \qquad (3)$$

Hence, the square of the difference of the two roots of the quadratic equation $Q^2 - 3PP' = 0$, multiplied by A^2, is equal, when its sign is changed, to three times the product of the squares of the differences of the roots of the cubic equation (2). We deduce, moreover, the conclusions following, namely:—

1. If $B^2 = 4AC$, that is, if the two roots r_1, r_2, are *equal* roots, then also two roots of the cubic equation (2) must be equal roots, seeing that *one*, at least, of the differences furnished by the three roots must then be zero. These latter equal roots must be the same as the former (r_1, r_2): for, representing one of the equal roots of (2) by r, the expressions Q^2, and $3PP'$, must each be divisible by $(x - r)^2$; and consequently,

$$Q^2 - 3PP', \text{ that is, } Ax^2 + Bx + C$$

must also be divisible by $(x - r)^2$. But this expression (under the stipulated condition, namely, the condition $r_1 = r_2$), is divisible by no quadratic factor other than $(x - r_1)^2$; therefore, $x - r$ and $x - r_1$ must be identical: hence the equations $P = 0$ and $Q^2 - 3PP' = 0$ must have the same pair of equal roots. [When *all* the roots are equal, $Q^2 = 3PP'$; and there is no remainder].

2. If $B^2 > 4AC$, that is, if the roots r_1, r_2, of the equation $Q^2 - 3PP' = 0$ are real and unequal, the sign of $B^2 - 4AC$ will be *plus*; and therefore the sign of the product of the squares of the differences of the roots of the equation $P = 0$, or (2), must be *minus*; which can be the case only when $P = 0$ has a pair of imaginary roots. Whenever C is *minus* (the co-efficient A being *plus*), the sign of $B^2 - 4AC$ will necessarily be *plus*; as also when C is zero. The sign must also be *plus* whenever A and C are *both minus*; since if, under these conditions, $B^2 - 4AC$ could be *minus*, the roots of $Q^2 - 3PP' = 0$

would be imaginary; and therefore (having regard to the prefixed *minus* sign) the expression $Q^2 - 3PP'$ would be negative, whatever real value be given to x. But for that value of x which makes $P = 0$, as also for that which makes $P' = 0$, this expression is *positive;* hence it is impossible, in the case supposed—the case, namely, in which A and C are both *minus*, that the sign of $B^2 - 4AC$ can ever be *minus*. Whenever, therefore, C is *minus*, whichever be the sign of A, the equation $P = 0$ must have a pair of imaginary roots.

3. If $B^2 < 4AC$, that is, if the roots r_1, r_2, of $Q^2 - 3PP' = 0$, are imaginary, the sign of $B^2 - 4AC$ will be *minus;* and therefore, the sign of the product of the squares of the differences of the roots of (2), or $P = 0$, must be *plus*, which can be the case only when all the roots of $P = 0$ are *real*.

And in this way are established the theorems arrived at in a very different manner in my Paper "On the Imaginary Roots of Numerical Equations."* The theorems themselves, as here arrived at, are but so many inferences from the property which it was the main purpose of this communication to prove, namely, as shown above, that

$$\frac{B^2 - 4AC}{A^2},$$

or, which is the same thing, that $(r_1 - r_2)^2$ is equal to

$$-3(R_1 - R_2)^2(R_1 - R_3)^2(R_2 - R_3)^2,$$

where R_1, R_2, R_3, are the three roots of the cubic equation $P = 0$, and r_1, r_2, are the two roots of the quadratic equation

$$Q^2 - 3PP' = 0, \text{ or } Ax^2 + Bx + C = 0,$$

deduced from this cubic. And although particular examples are never necessary to verify a demonstrated general truth, yet as such examples are often acceptable illustrations of theory, I shall here subjoin one or two.

1. The roots of $x^3 + 10x^2 + 31x + 30 = 0$ are

$$-2, -3, -5;$$

and the expression $Q^2 - 3PP'$ is

$$Ax^2 + Bx + C = 7x^2 + 40x + 61;$$

$$\therefore B^2 = 40^2 = 1600, \text{ and } 4AC = 4 \times 7 \times 61 = 1708,$$

and the difference, $B^2 - 4AC$, is -108, and $\frac{-108}{3} = -36$.

The differences of the roots of the equation are

$$-2 + 3, -2 + 5, \text{ and } -3 + 5;$$

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* *Vide* Proceedings R. I. Acad., vol. x., Series I., p. 343 (1866–69).

the squares of which differences are

$$1^2,\ 3^2,\ 2^2;\ \text{and the product of these is } 36;$$

and the former result, when its sign is changed, is the same number.

2. The roots of $x^3 - 4x^2 + 3x + 2 = 0$ are

$$2,\ 1+\sqrt{2},\ 1-\sqrt{2};$$

and the expression $Q^2 - 3PP'$ is

$$Ax^2 + Bx + C = 7x^2 - 30x + 33;$$

$$\therefore\ B^2 = 900, \text{ and } 4AC = 924;$$

$$\therefore\ B^2 - 4AC = -24;\ \text{and } \frac{-24}{3} = -8.$$

The differences of the roots are

$$1-\sqrt{2},\ 1+\sqrt{2},\ 2\sqrt{2};$$

and the product of these differences is $-2\sqrt{2}$, of which product the square is 8; the same as the former result when its sign is changed.

3. It may be well to work out this final example in more detail:

$$P = x^3 + 11x^2 - 102x + 181 = 0$$
$$Q = 3x^2 + 22x - 102$$
$$P' = 3x + 11.$$

Multiplying Q by itself, and omitting terms in x^3 and x^4,

$$\begin{array}{l} 3x^2 + 22x - 102 \\ 3x^2 + 22x - 102 \\ \hline 484x^2 - 612x^2 - 4488x + 10404 \end{array}$$

$$\therefore\ Q^2 = -128x^2 - 4488x + 10404.$$

In like manner, multiplying P by P',

$$\begin{array}{l} x^3 + 11x^2 - 102x + 181 \\ 3x + 11 \\ \hline 121x^2 - 306x^2 - 1122x + 543x + 1991 \end{array}$$

$$= -185x^2 - 579x + 1991 = PP'$$

$$\therefore\ Q^2 - 3PP' = 427x^2 - 2751x + 4431 = Ax^2 + Bx + C;$$

$$\therefore\ B^2 = 7568001$$
$$4\,AC = 7568148$$
$$-447 = B^2 - 4AC.$$

Therefore three times the product of the squares of the differences of the roots of the equation $P = 0$ is $+ 147$. Also

$$\frac{-147}{427^2} = (r_1 - r_2)^2;$$

r_1, r_2 being the two roots of $427x^2 - 2751x + 4431 = 0$.

These two roots would, of course, remain unaltered, although the co-efficients of the equation $Ax^2 + Bx + C = 0$ were each multiplied or divided by any number; but the numerical result, $B^2 - 4AC$, would be changed by such multiplication or division, and would no longer express three times the product of the squares of the differences of the roots of $P = 0$. The *sign* of the numerical result would, however, be the same; and therefore, for the purpose of ascertaining the *character* of the roots of the cubic equation $P = 0$, the co-efficients of the quadratic equation $Q^2 - 3PP' = 0$ may always be reduced to smaller numbers whenever they have a common factor. Thus, in the present example, we see that the co-efficients in the expression $Q^2 - 3PP'$ are each divisible by the number 7; so that we may write

$$61x^2 - 393x + 633 = A'x^2 + B'x + C',$$

$$61x^2 - 393x + 683 = A'x^2 + B'x = C',$$

and thus get

$$B'^2 - 4A'C' = 15449 - 154452 = -3\text{; and } \frac{-3}{61^2} = (r_1 - r_2)^2;$$

this last result being the same as $\frac{-147}{427^2} = (r_1 - r_2)^2$.

It is obvious that if K denote the number by which each of the co-efficients A, B, C, is divided, in any case, K^2 times $B'^2 - 4A'C'$ will be equal to $B^2 - 4AC$; that is (changing the sign), to three times the product of the squares of the differences of the roots of the equation $P = 0$; in which equation, it is to be observed that the co-efficient of x^3 is *unity*. If the co-efficient of x^3, in the proposed cubic equation, be A_3, a number different from unity, then it is

$$\frac{A_3^2}{A_3^4}(r_1 - r_2)^2, \text{ or } \frac{B^2 - 4AC}{A_3^4},$$

which, with changed sign, is equal to three times the product of the squares of the differences of the roots of the cubic equation; that is, of the equation

$$P = A_3x^3 + A_2x^2 + A_1x + A_0 = 0;$$

because the co-efficients A, B, C, as deduced from *this* equation, are each A_3^2 times what they would be if the co-efficient of x^3 were reduced to unity by the terms of the equation being each of them divided by A_3.

Take, for instance, the equation following:—

$$P = 2x^3 - 3x^2 - 7x + 5 = 0,$$

one of the roots of which is found to be 2·5 (*Analysis and Solution of Cubic and Biquadratic Equations*, p. 179). To obtain the remaining roots we proceed thus:—

$$\begin{array}{l} 2 - 3 - 7 + 5\,(2{\cdot}5 \\ \quad 5 \quad 5 - 5 \\ \overline{2} - \overline{2} \quad \overline{0} \;\therefore\; 2x^2 + 2x - 2 = 0, \text{ or } x^2 + x - 1 = 0, \end{array}$$

which equation gives, for the other two roots of the equation $P = 0$,

$$x = -\frac{1}{2} + \frac{1}{2}\sqrt{5}, \quad x = -\frac{1}{2} - \frac{1}{2}\sqrt{5};$$

so that the product of the squares of the differences is

$$\left(3 - \frac{1}{2}\sqrt{5}\right)^2 \left(3 + \frac{1}{2}\sqrt{5}\right)^2 (\sqrt{5})^2 = \left(9 - \frac{5}{4}\right)^2 \times 5 = \frac{4805}{16} \quad \ldots\ldots \quad (1)$$

Again: $Q^2 - 3PP' = Ax^2 + Bx + C = 51x^2 - 69x + 94$; therefore,

$$\frac{B^2 - 4AC}{A_3^4} = \frac{4761 - 19176}{16} = \frac{-14415}{16}; \quad \ldots\ldots\ldots \quad (2)$$

and, changing the sign of this, (1) × 3 = (2).

The square of the difference of the two roots r_1, r_2, of the equation

$$Ax^2 + Bx + C = 0$$

is of course

$$(r_1 - r_2)^2 = \frac{B^2 - 4AC}{A^2} = \frac{69^2 - 204 \times 94}{51^2} = \frac{-14415}{51^2};$$

which, multiplied by $\frac{A^2}{A_3^4}$, that is, by $\frac{51^2}{16}$, gives $\frac{-14415}{16}$, the same result as that marked (2) above; and which, by the expression (1), is three times the product of the squares of the differences of the roots of the equation $P = 0$, when the sign of this product is changed.

It may not be superfluous to remark here, that the relation established in this Paper between the product of the squares of the three roots R_1, R_2, R_3, of a cubic equation,

$$P = A_3x^3 + A_2x^2 + A_1x + A_0 = 0, \quad \ldots\ldots\ldots\ldots \quad (1)$$

and the square of the difference of the two roots r_1, r_2, of the quadratic equation

$$Q^2 - 3PP' = 0\text{; that is, of } Ax^2 + Bx + C = 0\,, \ldots\ldots\ldots\ldots (2)$$

the relation—namely,

$$\frac{A}{A_3^4}(r_1 - r_2)^2 = \frac{B^2 - 4AC}{A_3^4} = -3(R_1 - R_2)^2(R_1 - R_3)^2(R_2 - R_3)^2, \ldots\ldots (3)$$

can subsist only when the equation $Q^2 - 3PP' = 0$ has two roots; that is to say, only when A is a significant number. If A be *zero*, the equation (2), being then of only the first degree, has but *one* root, and the first member of (3) is nugatory; but the second member remains significant; it is $B^2 \div A_3^4$. But if C be zero, and A a significant number, one root (r_2) of the quadratic equation will be zero; and the first and second members of (3) will then be

$$\frac{A^2}{A_3^4}r_1^2, \text{ and } \frac{B^2}{A_3^4},$$

implying that when the quadratic equation $Q^2 - 3PP' = 0$ is

$$Ax^2 + Bx = 0,$$

three times the product (with changed sign) of the squares of the differences of the roots of (1) is equal to $\frac{B^2}{A_3^4}$, or simply to B^2, or $A^2r_1^2$, if the co-efficient A_3, in (1), is unity.

For example: suppose we have the equation

$$P = x^3 + 3x^2 - 6x + 4 = 0,$$

where the second triad of co-efficients furnishes the condition

$$A_1^2 - 3A_0A_2 = 0.$$

The equation $Q^2 - 3PP' = 0$, here, is found to be

$$Ax^2 + Bx + C = 27x^2 - 54x = 0\,;$$

in which the values of x are $x = 0$, and $x = r_1 = 2$.

Now, if each of the roots of the equation $P = 0$ be diminished by -1, the second term will disappear in the transformation, which will be the equation

$$x^3 - 9x + 12 = 0\,;$$

and the product of the squares of the differences of the roots of *this* equation, when the sign of that product is changed, is (by p. 410, *Theory of Equations*) $4p^3 + 27q^2$, where, in the present case, $p = -9$, and $q = 12$. Hence, three times the product of the squares of the differences of the roots of $P = 0$ is

$$(-2916 + 3888) \times 3 = 2916 = 54^2 = B^2 = A^2 r_1^2.$$

If A and C be *each* of them zero, then B itself will be zero; and P will be a complete cube, or a complete cube multiplied by a numerical factor. It was shown in my Paper (read November 9, 1868) that P being $A_3 x^3 + A_2 x^2 + A_1 x + A_0$, $Q^2 - 3PP'$ is

$$(A_2^2 - 3A_1A_3)\,x^2 + (A_1A_2 - 9A_0A_3)\,x + (A_1^2 - 3A_0A_2);$$

and that the two conditions

$$A_2^2 - 3A_1A_3 = 0, \text{ and } A_1^2 - 3A_0A_2 = 0,$$

necessitate the third condition

$$A_1A_2 - 9A_0A_3 = 0,$$

will be seen by transposing the minus term of each, and then multiplying the results together; for we shall thus have

$$A_1^2A_2^2 = 9A_0A_1A_2A_3;$$

and, consequently,

$$A_1A_2 = 9A_0A_3:$$

so that, when the two foregoing conditions have place, the expressions Q^2 and $3PP'$ must be identical; and, therefore, P must be of the form $A_3(x+a)^3$.

I shall now give a simple and direct proof of the property referred to (already otherwise established) at the commencement of the present Paper—namely, that if D^2 represent the product of the squares of the differences of the roots of the equation

$$x^3 + px + q = 0 \quad . \; . \; . \; . \; (1),$$

we shall always have

$$D^2 = -(27q^2 + 4p^3).$$

Demonstration.—It is shown in the *Theory of Equations*, p. 322, that if x_1 be either of the roots of the equation (1), all three of the roots will be

$$x_1,\; -\frac{1}{2}x_1 + \sqrt{\left(-3\frac{x_1^2}{4} - p\right)},\; -\frac{1}{2}x_1 - \sqrt{\left(-3\frac{x_1^2}{4} - p\right)}.$$

Now, the differences of these are

$$\frac{3}{2}x_1 - \sqrt{\left(-3\frac{x_1^2}{4} - p\right)},\; \frac{3}{2}x_1 + \sqrt{\left(-3\frac{x_1^2}{4} - p\right)},\; 2\sqrt{\left(-3\frac{x_1^2}{4} - p\right)} \ldots (2),$$

and, therefore, the product of the squares of the differences is

$$\left\{\left(\frac{3}{2}x_1\right)^2 + 3\frac{x_1^2}{4} + p\right\}^2 \left\{-4\left(3\frac{x_1^2}{4} + p\right)\right\} = D^2,$$

$$\therefore 4\left\{\frac{9x_1^2}{4} + 3\frac{x_1^2}{4} + p\right\}^2 \left\{3\frac{x_1^2}{4} + p\right\} = -D^2;$$

that is,

$$(3x_1^2 + p)^2 (3x_1^2 + 4p) = -D^2,$$

or,

$$27x_1^6 + 54px_1^4 + 27p^2x_1^2 + 4p^3 = -D^2,$$

$$\therefore x_1^6 + 2px_1^4 + p^2x_1^2 = \frac{-D^2 - 4p^3}{27};$$

that is,

$$(x_1^3 + px_1)^2 = \frac{-D^2 - 4p^3}{27};$$

But by the equation (1), $(x_1^3 + px_1)^2 = q^2$; therefore,

$$D^2 = -(27q^2 + 4p^3).$$

From the foregoing results we may deduce the equation of which the roots are the squares of the differences of the roots of the equation (1), with remarkable facility, thus:—Let

$$z^3 + az^2 + bz + c = 0$$

represent the equation of which the three roots are the squares of the three expressions (2), in which expressions, x_1 is either one, indifferently, of the three roots of the equation (1). Then the co-efficient a will denote the sum of the squares of the three expressions (2), when the sign of each square is changed; the co-efficient b will denote the sum of the products, taken two and two, of these same squares, whether the signs of them be changed or not, since the resulting products are the same; and c will denote the product, with changed sign, of all three of the squares.

Now, each of these co-efficients has but a single definite value; so that no quantity involving x_1 (which has a threefold value) can enter any of them, except, indeed, the quantity be of the form

$$m(x_1^3 + px_1)^n = m(-q)^n,$$

where n is a whole number, and m a numerical factor; because only then, and when x_1 is entirely absent (in consequence of the terms involving x_1 neutralising one another), can the co-efficients a, b, c, have, each of them, single unambiguous values.

It is plain, from inspection, that *the sum of the squares* of the expressions (2) cannot involve x_1^3; therefore, this sum must be the same as it would be if x_1 were zero; that is to say, the sum is

$$(\surd - p)^2 + (\surd - p)^2 + 4(\surd - p)^2 = -6p \therefore a = 6p.$$

Again: *the sum of the products*, two and two, of the squares of the expressions (2), cannot involve x_1^3, seeing that the middle term (the term involving $\surd$), in the square of the first expressions (2), is the same, with opposite sign, as the middle term (the term involving $\surd$), in the square of the second of the expressions (2). Hence, if each of these squares be multiplied by the square of the third of the expressions (2), and the two products be added together, the terms involving $\surd$ will disappear; and the result will involve only *even powers* of x_1. And it has been already shown that the product of the squares of the first and second of the expressions (2) is $(3x_1^2 + p)^2$; which, in like manner, contains only *even* powers of x_1. Therefore, the sum of the three products must be the same as it would be if x_1 were zero; that is to say, the sum of the products is

$$p^2 + 4p^2 + 4p^2 = 9p^2, \therefore b = 9p^2;$$

and it has been already proved that the product of all the squares is

$$-(27q^2 + 4p^3), \therefore c = 27q^2 + 4p^3.$$

Consequently, the equation of the squares of the differences is

$$z^3 + 6pz^2 + 9p^2z + 4p^3 + 27q^2 = 0,$$

the equation which Lagrange has arrived at in a very different manner.

[*Note added in Press.*—The following somewhat remarkable truth is an immediate inference from Article (12) in my last Paper, namely:—

In a cubic equation of which the roots are real, although each root of the derived quadratic always lies between two roots of the cubic, yet it is impossible that either of the two roots of the quadratic can ever lie *midway* between the two neighbouring roots of the cubic.]

LXI.—On a New Genus and Species of Sponge. By Ed. Percival Wright, M. A., M. D., F. L. S., Professor of Botany and Keeper of the Herbarium, University of Dublin. (With Plate 40.)

[Read May 8, 1876.]

While working over the very large and valuable collection of Algæ which is under my care in the Herbarium of Trinity College, my attention has often been attracted by the large number of animal remains, to be seen either adherent to or nestling among the fronds of certain species. Not to allude to a vast number of species of Polyzoa, which are often endophytic to such an extent as to render the species of Algæ impossible to be determined; species belonging to the Pycnogonidæ, Zoanthidæ, &c. are often very numerous, and sometimes large numbers of sponges and foraminifera will be met with.

Of the sponges, the species as a rule belong to forms with either a calcareous or a horny-fibrose framework: very rarely, and then only at the root-like extremities of some of the larger forms, have I met with siliceous sponges.

The little form that I venture to describe here as new was first known to me from observing portions of its stem, as in figure 3, Plate 40, often without a trace of any body portion, and at a glance, and using only a hand lens, I thought it must belong to some novel pentacrinoid form. A closer examination showed the fibrous nature of the stem portion, and after a while more or less perfect specimens were discovered, which left no doubt but that they belonged to a sponge. A careful microscopical investigation showed that there were no spicules, but it will be recollected that I had nothing but the well dried and often flatly pressed specimens to examine; still these were found, for the most part, on species of Delesseria which had been freshly gathered by Professor Harvey on the Australian shores, and it is not very probable that any large portion of the substance of the sponge had disappeared. A few siliceous spicules were now and then to be seen, but evidently got to be entangled, as foreign bodies, in the sponge mass.

The following may serve as a diagnosis of the genus:—

Kallispongia, gen. nov.

Sponge substance keratose, consisting of three distinct and well-marked portions; firstly, a small basal disk; secondly, an elongated stem, on the summit of which expands the third portion or capitulum. The disk is button-shaped, flat, and is formed of an irregular horny framework, twice to three times as broad as the stem. The stem varies in height, and presents the appearances in some cases of a series of margined rings, some twenty in number, fastened together one on the top of the other; in others the margins of the rings will be more prominent, and the bodies of the rings will be, as it were, more deeply sunk. In both these cases the horny framework is of a more or less evenly latticed character, the longitudinal lines of the lattice being very prominent.

The head portion, in its natural state must, I think, present a more or less spherical form, perhaps slightly flattened on the summit, with an indication of being divided into four nearly equal parts—the open space between these leading into the body cavity of the sponge. In some of the specimens the head portion nearest to the stem seems to have been formed of a somewhat denser framework than the upper portion, so that while being pressed this upper portion has been fractured across (*vide* fig. 1). The framework here is of a densely reticulated kind, in appearance reminding one of the reticulated network of the intracapsular sarcode in Thalassolampe, or of the tissues met with in some Echinoderms.

Kallispongia Archeri, sp. nov.

The description of the genus will, for the present, serve for the species; specimens vary from two to three millimetres in height.

Localities—growing on the fronds of various species of Florideæ; gathered on the coasts of Australia by Professor W. H. Harvey, about 1854.

The beauty and novelty of this little sponge—the largest specimens measure but three millimetres in height—must plead my excuse for publishing a description of a form that may possibly turn out to be but a very young stage of some other species.

It is true that it is by far the smallest of all known keratose sponges, but I do not think that its size necessarily militates against the possibility of its being a good species. Why should there not be very minute keratose as well as very minute calcareous sponges? and although I did once before,* perhaps somewhat prematurely, describe a young stage of a siliceous sponge, now that its mature form is well known, I perceive that the difference between the young and adult form has not been so great as to suggest the idea of there being a change or metamorphosis, such as one might *a priori* have expected, in the group of the sponges.

Kallispongia Archeri appears to me too to have a rather fixed and definite physiognomy, and I can easily fancy its going through all the phases of its life history—this being the persona-stage, amid the thallus of its fostering alga—after the manner of some of the minute calcareous sponges described by Haeckel.

One very marked variety of stem outline (fig. 3) I have met with; it forms a very exquisite microscopical object. The stem puts one in mind of the string of frustules of a Melosira or of Didymoprium

* Quarterly Journal of Microscopical Science, January 1870, p. 1, Pl. 2.

Brebissonii among the Desmids. The basal disk and capitulum seem to differ in no respect from the typical form, and until some time or other the species can be examined in a living state, this may be regarded as a variety of the above described form.

The species I have named after my friend William Archer, F. R. S., so well known for his researches among the lower forms of vegetable and animal life. His researches among the Rhizopods are of such value, that one could wish that he would extend them to animals one step higher in the scale, and so favour science with a series of observations on the sponges.

The wonderful mimetic resemblance which this new species bears to some of the stages of development of a Crinoid can scarcely be overlooked. Leaving the texture and composition of the skeleton mass for the moment out of view, and simply looking at its outline—the circular disk-like base—the stem—the profile of which is absolutely the same, except as to size, as that of the pentacrinoid stage of Antedon rosaceus, and the slightly cleft head, the resemblance, to my mind, is very great. Often, indeed, have I been obliged to look, and look again, and to crush down the specimen, before I could convince myself, by a full view of its texture, that I was not deceived. So far as I know, this is a unique case among the sponges, and one is let to wonder what may be the tiny enemies from which Kallispongia Archeri, by this complete disguise, conceals itself.

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PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY.

VOL. II., SERIES 2.

SCIENCE.

DESCRIPTION OF PLATES.

PLATE 1.

Illustrative of Professor Macalister's Paper on "The Presence of a Lachrymo-jugal Suture in a Human Skull, and on its Comparative Anatomy."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 58.

Fig. 1. Human skull.
- Mx. Maxillary bone.
- Mx.* Superior maxillary.
- L. Lachrymal bone.
- E. Ethmoid.
- J. Jugal Bone.

Fig. 2. Rhesus.
- Mc. Maxillary bone.
- L. Lachrymal bone.
- Fr. Frontal bone.
- J. Jugal bone.
- P. Parietal.
- S. Squamous portion of Temporal.
- Z. Zygomatic process of Temporal.
- I. Supra-orbital foramen.

PLATE 2.

ILLUSTRATIVE OF PROFESSOR MACALISTER'S PAPER "ON TWO NEW SPECIES OF PENTASTOMA."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 62.

Fig. 1. ***Pentastoma imperatoris***, sp. nov. female, nat. size.

2. ,, ,, male, × 4—*a*. mouth; *b*. intestine.
3. ,, ,, female head—*a*. papillæ; *b*. dorsal wart.
4. ,, ,, ,, claw, × 50, showing retractor and depressor muscles.
5. ,, ,, ,, reproductive organs—*a*. coiled oviduct; *b*. receptacula seminis; *c*. ovarian ducts; *d*. ovary; *e*. uterus.
6. ,, ,, male reproductive organs × 18—*a*. œsophagus; *b*. accessory sacs containing chitinous processes; *c*. cirrhus; *d*. sac of ditto; *e*. accessory gland; *f*. point where the vas deferens ends in the cirrhus; *g*. end of cirrhus.
7. ,, ,, striped muscle from retractor of claw × 350.
8. ,, ,, vertical section of part of body wall; *a*. chitinous epidermis; *b*. hypodermis; *c*. longitudinal muscle; *d*. circular ditto; *e*. lining membrane; *f*. body cavity; *g*. wall of oviduct; *h*. ova.
9. ,, ,, section of intestine × 15, partly diagrammatic.
10. ,, ,, portion of oviduct above uterus.
11. *Pentastoma aonycis*, sp. nov. female × 6.
12. ,, ,, mouth.
13. ,, ,, claw × 50.

PLATE 3.

ILLUSTRATIVE OF PROFESSOR MACALISTER'S PAPER "ON TWO NEW SPECIES OF PENTASTOMA."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 62.

Figs. 1 to 13. *Pentastoma imperatoris*, sp. nov. representing different stages of Ova and Embryos.

Fig. 14. *Pentastoma aonycis*, sp. nov., portion of skin of, × 100.

PLATE 4.

ILLUSTRATIVE OF MR. W. H. MACKINTOSH'S PAPER "ON THE MUSCULAR ANATOMY OF CHOLŒPUS DIDACTYLUS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 66.

Cholœpus didactylus, muscles of hind limb.

- *a*. Panniculus.
- *b*. External oblique.
- *c*. Iliacus.
- *d*. Sartorius femoralis.
- *e*. Adductor magnus (the rectus is seen just above).
- *f*. Bifid gracilis.
- *g*. Biceps femoris.
- *h*. Flexor hallucis and flexor longus.
- *i*. Two tendons of gastrocnemius externus.

PLATE 5.

ILLUSTRATIVE OF MR. G. R. LEEPER'S PAPER ON "RETRO-PERITONEAL CAVITIES IN MAN."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 79.

Fig. 1. Recessus Ileo-cœcalis.
2. Fossa subcœcalis.
3. Fossa retro-cœcalis.

C. Cœcum. I. Ileum. I. c. Ileo-colic Artery. K. Knife passed through the long mesocœcum. Mc. Mesocœcum. Mm. Mesenteriolum. My. Mesentery. P. i. c. Plica Ileo-cœcalis. P. m. Cut edge of the Peritoneum. Ps. Psoas magnus. Ps'. Psoas parvus tendon. F. s. c. Fossa subcœcalis. Fi. Fascia iliaca. R. Fossa retro-cœcalis. R. i. c. Recessus ileo-cœcalis. T e. Tænia externa. V. a. Vermiform appendix.

PLATE 6.

ILLUSTRATIVE OF MR. ARCHER'S PAPER "ON APOTHECIA IN SOME SCYTONEMACEÆ AND SIROSIPHONACEÆ."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 85.

Fig. 1. Ascus with 4 spores.
2. Single spore × 403.

From an unidentified *Scytonema*.

3, 4, 5. Apothecia.
6. Mature apothecium.
7. Same (in outline) burst, to show protruding asci and paraphyses.
8. Spore × 400.
9–11. Showing internal agglomeration of brownish-coloured granules causing swellings of the filaments (incipient apothecia ?)

From *Sirosiphon alpinus*.

12. Fully formed apothecium.
13. Younger apothecium.
14. Spore × 400.
15. Ascus, immature, with paraphyses, showing contents contracted into a fusiform figure and divided transversely.
16, 17. Immature asci with paraphyses.
18. Showing portion of an apothecium burst so as to cause the 8-spored asci, with paraphyses, to become extruded (the rent portion of the apothecium not shaded).

From *Sirosiphon pulvinatus* or *S. Heufleri*.

19. Immature apothecium.
20. Outline of mature apothecium.
21. Immature asci.
22. Mature ascus with 8 spores.
23. Spore × 400.

From *Stigonema mamillosum*.

24. Apothecium.
25. Immature asci with paraphyses.
26. Spore × 400.

PLATE 7.

ILLUSTRATIVE OF MR. KINAHAN'S PAPER "ON MICROSCOPICAL STRUCTURE OF ROCKS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 94.

Fig. 1. Orthoclase (F. Rutly), Yetterly, Sweden (42 diam.)

2. Junctions of twin crystals of flesh-coloured felspar (Knockanavaddy), Co. Galway (42 diam.)
3. Crystals of amphibole and mica in the flesh-coloured felspar (42 diam.)
4. Inlying crystalline mass in the flesh-coloured felspar (42 diam.)
5. Crystals of magnetite (?) and pyrite in the flesh-coloured felspar (296 diam.)
6. A portion of one of the small crystals of the flesh-coloured felspar (42 diam.)
7. A portion of a mass of the dull white felspar (adularia ?) from the Knockanavaddy granite, showing contained portions of a triclinic felspar (oligoclase ?) that have a ribanded structure 42 diam.)
8. A crystalline mass of adularia (?) in which there is an incipient or faint lining (42 diam.)
9. A portion of a crystal of oligoclase (F. Rutly) Yetterly, Sweden, showing its structure (42 diam.)
10. Portions of crystals of triclinic felspar (oligoclase) from the Knockanavaddy granite (42 diam.), (*aa*) irregular flakes of mica, (*b*) small crystals of titanite, (*c*) roundish piece of flesh-coloured orthoclase.
11. Part of a large crystal of titanite with which are two small crystals of the same mineral, one an inlier (42 diam.)
12. Dull white felspar crystals (adularia)—Furbogh, Galway—showing peculiar structure (238 diam.)

PLATE 8.

ILLUSTRATIVE OF MR. KINAHAN'S PAPER "ON MICROSCOPICAL STRUCTURE OF ROCKS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 94.

Fig. 13. A portion of the lower right-hand crystal in Fig. 12, Pl. 7, enlarged 386 diameters.

14. Inlying minerals in the triclinic felspar Furbogh granite (238 diam.)
15. Peculiar structure of the triclinic felspar, 196 diameters.
16. Part of Fig. 15, marked (*b*), enlarged 386 diameters.
17. Peculiar structure of the triclinic felspar, 296 diameters.
18. Blebs of quartz in the Kilkullen granite (42 diam.), right-hand a crystal, left hand, the quartz having a pellicle.
19. Blebs of quartz in Elvanyte, from near Galway (42 diam.), right hand, a crystal, left-hand, irregular secretion with a pellicle.
20. Part of Fig. 18, marked (*a*), magnified 196 diameters.
21. Part of Fig. 20, marked (*a*), magnified 386 diameters.
22. Part of Fig. 18, marked (*b*), magnified 296 diameters. In the lower right-hand portion of the figure are five tubes from the feather-shaped arrangement a little to the left, which are magnified 386 diameters.
23. A portion of the centre of the right-hand crystal in Fig. 19, magnified about 350 diameters, to show the *tubuli* or short gas tubes. The two pointed cones below the tubes are oblique sections of tubes.
24. A portion of some of the quartz of the Furbogh granite, magnified 240 diameters, showing *capilloids*, or hair-like lines and regular systems of tubuli. In the upper left-hand portion of the figure is an inlying crystal.

PLATE 9.

ILLUSTRATIVE OF MR. KINAHAN'S PAPER "ON GRANITIC AND OTHER INGENITE ROCKS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 102.

A. Diagrammatic sketch of a doleryte dyke, seeming one rock, but of different textures in different parts—*a* and *b*, clay or shale partings; *c* and *d* caught up pieces of schist. In the vicinity of the parting *b*, the rock is amygdaloidal, while the division of the dyke on the left of that parting has a rude horizontal columnar structure combined in places with a spheroidal structure. The arm to the left has a rude columnar structure.—Cleggan.

B. Diagrammatic sketch of a doloryte dyke in felsite-schist, showing a platy and spheroidal structure.—Mannic Bay.

C. Sketch-map of part of a dyke of felstone in granite. In the whole of the felstone is a structure oblique to the walls of the dyke, while in part are lines nearly perpendicular to the others, giving the rock a tesselated aspect.—Lough Bola.

D. Nodular or conglomeritic-gneiss, changing into granitoid-gneiss.—Derrycemlagh.

E. Angular pieces of schistoid-granite in intrusive oligoclasic-granite.—Omey Island.

F. Section of conglomiretic-schist.—Ardadeny.

G. Sketch-map of a small rock exposure, showing scaled old joint-lines in a hornblende-aphanyte.—Letterdife.

H. Sketch-map of a small rock exposure, showing some of the old joint-lines scaled, while others are still open, but a small thickness of rock alongside is indurated, and when the rock is weathered stands up in a ridge.—Glan.

I. Sketch-map of a small exposure of micaceous-hornblende-rock, showing the pitted surface caused by the weathering out of the small bunches of mica plates.—Knockadai.

J. Sketch-map of a weathered surface of a micaceous-hornblende-rock containing large flakes of silvery-white mica, the weathered edges of the latter having a peculiar angular arrangement.—Mannin Bay.

PLATE 10.

ILLUSTRATIVE OF MR. KINAHAN'S PAPER "ON GRANITIC AND OTHER INGENITE ROCKS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 102.

K. Sketch of a bomboid protrusion of hornblende-aphanyte in a mass of steatyte.—Inish Bofin.

L. Diagrammatic sketch of a section showing hornblende-rock associated with hornblende-schist, the latter alternating upwards with mica-schist; (*a*) mica-schist; (*b*) Hornblende-schist; (*c*) hornblende-rock.—Derrycunlagh.

M. Nodular hornblende-rock passing upwards into conglomeritic-gneiss.—Derrycunlagh.

N. Nodular hornblende-rock passing at the edge of the flow or bed into conglomeritic-gneiss.—Derrycunlagh.

O. Veins of segregation of three ages in orthoclasic-granite; (*a*) new open joints; (*b*) newest veins; (*c*) second veins; (*d*) oldest veins.—Cashla Bay.

P. Sketch-map of a rock-surface of hornblende-schist showing the old joint-lines forming hard lines, and the associated rock indurated.—Ardadeny.

PLATE 11.

ILLUSTRATIVE OF MR. KINAHAN'S PAPER "ON GRANITIC AND OTHER INGENITE ROCKS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 102.

Fig. Q. Map of Cashel Hill, showing the exotic rocks associated with tuff, while both are distinct from the rocks of the surrounding country.

PLATE 12.

Illustrative of Mr. Kinahan's Paper "On Granitic and other Ingenite Rocks."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 102.

Fig. R. Vertical section across the summit of Cashel Hill.

Fig. S. Section across Knocksufin, showing the graduation of the oligoclasic granite through gneiss into schists, and their relations to some of the exotic rocks.

PLATE 13.

ILLUSTRATIVE OF PROFESSOR MACALISTER'S PAPER "ON THE CRANIAL OSTEOLOGY OF SLOTHS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 139.

Fig. 1. ***Bradypus gularis***, **Skull, nat. size.**
- *a* Parietal.
- *b* Supra-occipital.
- *c* Squamosal.
- *d* Exoccipital.
- *e* Condyle.

Fig. 2. Ditto, ½ nat. size.
- *a* Lachrymal bone.
- *b* Nasal bone.
- *c* Frontal bone.
- *d* Parietal.
- *e* Squamosal.
- *f* Supra-occipital.
- *g* Occipital crest.
- *h* Exoccipital bone.
- *i* Condyloid foramen.
- *j* Bulla tympani.
- *k* Pterygoid.
- *l* Foramen ovale.
- *m* Zygomatic process of squamosal.
- *n* Jugal bone.
- *o* Maxilla.
- *p* Premaxilla.

Fig. 3, [illegible] Fontanelle bones, nat size.
- *a* Wormian bones.
- *b* Left parietal bone.
- *c* Right parietal bone.
- *d* & *e* Wormian bones.
- *f* Supra-occipital left.
- *g* Meso-occipital suture.
- *h* Supra-occipital right.

Fig. 4. Fronto-lachrymal region × 4.
- *a* Jugal.
- *b* Lachrymal.
- *c* Frontal.
- *d* Maxilla.
- *e* Lachrymal foramen.
- *f* Infra-orbital foramen.

Fig. 5. × 12, Stapes.

PLATE 14.

ILLUSTRATIVE OF MR. ARCHER'S PAPER "ON CHLAMYDOMYXA LABYRINTHULOIDES, N. G. ET SP."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 140.

Plate 14 represents an entire example, the body-mass having become extruded through the torn-like opening in the many-layered outer envelope, and showing the greenish, reddish, and blueish-colouring granules, pulsating vacuoles, and some incepted foreign bodies. Far extending in a tortuous reticulated "labyrinth" are seen the *filamentary tracks* (Fadenbahn, Cienkowski) with numbers of the blueish granules travelling thereon, now becoming fusiform in figure (*Spindles*). Towards the left of the example, in an outlying portion of the mass is seen a vacuole showing a temporary cleft or rift in the substance at each side of it. Towards the right is seen a nearly isolated *colony* of the mass containing a digested example of *Oocystis Naegelii*. At the further extremity occur two similar nearly isolated portions, one showing imbedded an as yet undigested example of *Spirotænia gracillima* (n. s.), all these outlying portions showing some vacuoles. Towards the left of the figure a small portion of the body-mass has become on some former occasion independently re-encysted, and is now "dormant." × 400 diam.

PLATE 15.

ILLUSTRATIVE OF MR. ARCHER'S PAPER "ON CHLAMYDOMYXA LABYRINTHULOIDES, N. G. ET SP."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 140.

Fig. 1 shows certain bodies found in the cells of a Sphagnum occurring in the same pool [and often on the same plants, which harbour undoubted examples of this organism (as shown in next figure).] and which are supposed to have some genetic relationship.

Fig. 2.—A portion of a leaf of Sphagnum showing young *Chlamydomyxa* examples; to the left are seen green ones, near the bottom two very small, still globular, towards the middle a few now red, owing to the abundance of the red granules; the larger examples have put on a torulose figure, owing to the constriction caused by the recurring cincture of the annular fibre of the Sphagnum-cell. Towards the right is seen a *Chlamydomyxa* extruded, and still attached by a neck-like portion of the wall; the contents have become re-encysted now outside the Sphagnum-cell.

Fig. 3.—A condition rarely met with, showing the inner sarcodic substance subdivided in a number of nearly equal-sized globular portions, the sub-contents reddish inclining to orange, and each individual ball encysted in its proper wall; the whole within the outer many-layered original envelope.

Fig. 4.—The many-layered envelope of an example after severe pressure, the most of the substance removed, a few colouring granules only being left.

Fig. 5.—A small example after being boiled in caustic potash.

Fig. 6.—Portion of an example treated with iodine and sulphuric acid.

All the figs. × 200 diams.

PLATES 16 & 17.

ILLUSTRATIVE OF MR. BAKER'S PAPER "ON THE MYRTACEÆ OF THE SEYCHELLES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 160.

PLATE 16.—Eugenia Wrightii.

PLATE 17.—Eugenia Sechellarum.

PLATE 18.

ILLUSTRATIVE OF MR HARDMAN'S PAPER "ON THE CAVE OF DUNMORE, CO. KILKENNY."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 168.

Fig. 1. Plan of Cave.
2. The market cross stalactitic pillar.
3. Section at end of rabbit burrow. *Vide* p. 170.
4. Recess near market cross.
5. Fairies' floor.

PLATES 19 AND 20.

ILLUSTRATIVE OF MR. MACALISTER'S PAPER "ON SOME FORMS OF THE LIGAMENTUM PTERYGO-SPINOSUM."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 110.

[*In all the Figures the letters have the same significance.*]

E. External pterygoid plate.

I. Internal pterygoid plate.

A. Accessory external pterygoid plate (Fig. 12).

a. Spina accessoria (in Fig. 14 *a* = ligamentum pterygo-spinosum accessorium).

l. Lower spine on the external pterygoid plate.

m. Muscular ridge on the external pterygoid plate.

mm. Middle meningeal artery.

n. Notch between the two teeeh on the external pterygoid plate.

o. Foramen ovale. *o'*. Inner accessory opening thereinto.

p. Spina angularis.

r. Ridge of thickened ossified ligament.

s. Foramen spinosum.

t. Inner accessory aperture into foramen spinosum.

u. Upper tooth on the external pterygoid plate.

x. Suture on the ossified ligament.

PLATE 19.

Fig. 1. Outer view of outer pterygoid plate, adult male, showing a muscular ridge, and well marked, but separate spinæ angularis and accessoria.

2. Outer side of right outer pterygoid plate, showing two hinder teeth, as well as spinæ angularis and accessoria.

3. Inner side of right outer pterygoid plate, showing a large perforation (*f*) co-existing with a notch.

4. Outer view of right outer pterygoid plate, showing a deep notch.

5. Inner side of right pterygoid plates, showing lower and upper teeth.

6. Inner side of left pterygoid plates, showing a large projecting lower muscular tooth on the external pterygoid.

Fig. 7. Outer side of right external pterygoid, showing spina accessoria co-existing with a bridge across the foramen spinosum (*a′*).

8. Ossified ligaments forming a thick prominent ridge, on the outer and inner side of which are inlets into the oval and spinal foramina, which in vertical section are Y-shaped.

PLATE 20.

9. Ossified ligamentum pterygo-spinosum, showing a suture in the ossified bridge, co-existing with a spina accessoria.

10. Ossified ligamentum pterygo-spinosum accessorium, with a suture in the bridge of bone.

11. Ossified ligamentum pterygo-spinosum accessorium, bridging over, and dividing the inlet into the foramen ovale into two parts, spina angularis free, a back-directed spine from the spina accessoria overlapping the foramen spinosum.

12. Pterygoid processes from Chatham Island skull, showing the accessory outer pterygoid plate.

13. Ossified ligamentum accessorium pterygo-spinosum, with no suture.

14. Ligamenta pterygo-spinosum (*p. s.*) et accessorium (*a*), showing their relation to the middle meningeal artery (*m. m.*), and to the temporal nerves (*t′*, *t″*).

15. Ligaments in another specimen, showing their fusion at their pterygoid end.

PLATES 21 AND 22.

ILLUSTRATIVE OF MR. MACKINTOSH'S PAPER "ON A MALFORMED CORONA OF ECHINUS ESCULENTUS."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 114.

PLATE 21.—Fig. 1. Abactinal aspect of corona. I., II., III., IV., V., genital plates. 1, 2, 3, 4, 5, ocular plates. Plate I. is the madreporic; plate II. is seen to have lost its genital pore. *a*, right prong of ambulacrum 2, stopping short a little above the ambitus. (In this ambulacrum, in this and the next figure, the lithographer has in many instances represented as dots what are really small tubercles, and thus the pores seem much more numerous than they actually are). *a'*, a group of three or four pores belonging to ambulacrum *a*. *a''*, pores belonging to the left prong of ambulacrum *a*, which are placed inside the interambulacral plates of II*a*. *p*, large central plate round which a number of other plates are arranged in a radiate manner. *s*, a small perforation through the corona, apparently a hole produced by absorption.

Fig. 2. Corona seen from left-hand side. *a*, *a'*, as before; *b*, actinal boss. The point of bifurcation of ambulacrum 2 is seen near the bottom of the figure; also the remarkable "petaloid" appearance of interambulacrum II., and the scattered arrangement of the pores in the left prong of ambulacrum 2.

PLATE 22.—Fig. 3. Posterior aspect of corona, showing the remarkable alterations which the plates have undergone. References as before.

Fig. 4. Actinal aspect of corona. *a*, *b*, as before; the line *b* terminates on the summit of the boss. Ambulacrum 1 is seen to have a very short course, terminating a short distance beyond the top of the boss. The bifurcation of ambulacrum 2*a* is seen to take place about half way between the margin and the edge of the actinal orifice, the whole of which is displaced downwards and to the right-hand side. The sutures of the plates in the neighbourhood of the altered parts are almost entirely obliterated.

All the figures are reduced to about ⅘ the natural size.

PLATE 23.

ILLUSTRATIVE OF MR. M'NAB'S PAPER, "REMARKS ON THE STRUCTURE OF THE LEAVES OF CERTAIN CONIFERÆ."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 209.

Fig. 1. Pinus Hookeriana.
2. Pinus Pattoniana.
3. Pinus canadensis.
4. Pinus Mertensiana.
5. Pinus Brunoniana.
6. Pinus Sieboldii.

All the Figures are magnified 20 diameters.

e. Epidermis.
h. Hypoderma.
c. Resin canal.
s. Sheath of the Fibro-vascular bundles.

[*The letters refer to all the Figures.*]

PLATE 24.

ILLUSTRATIVE OF MR. MACALISTER'S PAPER "ON TWO DISSIMILAR FORMS OF PERITYPHLIC POUCHES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 214.

Fig. 1. Fossa Retrocæcalis.

a. Abdominal wall, cut and reflected.
b. External cutaneous nerve.
c. Ilio-inguinal nerve.
d. Fossa.
e. Crest of ilium.
f. Ascending colon, torn out of its bed.
g. Ureter.
h. Iliac artery.
i. Genito-crural nerve.
j. Psoas.

Fig. 2. Subcæcal Fossa.

a. Abdominal wall, cut and reflected.
b. Ligamentum cæci (Huschke).
c. Ascending colon.
d. Fossa ileo-cæcalis.
e. Ileum.
f. Rudiment of mesenteriolum.
g. Vermiform appendix.
h. Fossa sub-cæcalis.
i. Psoas magnus.

PLATE 25.

ILLUSTRATIVE OF MR. C. E. BURTON'S PAPER "ON THE ZODIACAL LIGHT."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 218.

Fig. 1. Represents the collective result of the observations on the spectrum of the Zodiacal Light detailed in the accompanying paper, laid down on a scale of wave-lengths. The unit of the scale employed for designating the lines is $\frac{1 \text{ millimetre}}{10^7}$; the same with that used by Ångström.

Fig. 2. The nucleus and envelopes of the Zodiacal Light. Mauritius, 1875, Jan. 2.

Fig. 3. The same as seen on 1875, Feb. 5, near the Equator.

Fig. 4. Do. do. Feb. 7.

Fig. 5. The same as seen in high N. latitude, 1875, March 31.

N.B.—In Figs. 2, 3, 4, 5, dark shading represents light.

PLATES 26 TO 34.

ILLUSTRATIVE OF THE REV. EUGENE O'MEARA'S REPORT "ON THE IRISH DIATOMACEÆ." Part I.

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 235.

PLATE 26.

Fig. 1. Melosira Borrerii, p. 246.
2. ,, subflexilis.
3. ,, distans.
4. Lysigonium nummuloides, p. 248.
5. Podosira montagnei, p. 250.
5a. ,, maculata.
6. Orthosira arenaria, p. 251.
7. ,, sulcata.
8. ,, orichalcea.
9. ,, Roëseana.
10. Cyclotella Kützingiana, p. 256.
11. ,, Meneghiniana.
12. ,, operculata.
12*b*. ,, ,, var.
13. ,, antiqua.
14. ,, rotula.
15. ,, papillosa.
16. ,, Scotica.
17. ,, punctata.
18. Coscinodiscus, oculus iridis, p. 260.
19. ,, centralis.
20. ,, perforatus.
21. ,, gigas.
22. ,, radiolatus.
23. ,, Gregorii.
24. ,, Ehrenbergii.
25. ,, minor.
26. Craspedodiscus coscinodiscus, p. 266.

PLATE 27.

Fig. 1. **Actinocyclus Ralfsii, p. 268.**
2. **" moniliformis.**
3. **Eupodiscus Argus, p. 269.**
4. **Auliscus sculptus, p. 270.**
5. **Odontodiscus excentricus, p. 270.**
6. **" Anglicus.**
7. **" Hibernicus.**
8. **Biddulphia Baileyii, p. 275.**
8a. **" aurita.**
9. **" pulchella.**
10. **Amphitetras antediluviana, p. 277.**
11. **Triceratium alternans, p. 278.**
12. **" amblyoceros.**
13. **" exiguum.**
14. **Trinacria regina, p. 278.**
15. **Isthmia nervosa, p. 279.**
16. **Fragilaria maxima, p. 283.**
17. **Denticula mutabilis, p. 285.**
18. **Odontidium mesodon, p. 287.**
19. **Dimeregramma distans, p. 289.**
20. **Plagiogramma costatum, p. 290.**

PLATE 28.

Fig. 1. **Diatoma grande, p. 291.**
2. **Ralfsia tabellaria, p. 293.**
3. **Rhaphoneis amphiceros, p. 295.**
4. **" scutelloides.**
5. **" liburnica.**
6. **Synedra crystallina, p. 297.**
7. **" fulgens.**
8. **" baculus.**

9. Synedra superba.
10. ,, amphicephala.
11. ,, investiens.
12. ,, acula.
13. ,, gracilis.
14. ,, undulata.
15. ,, lunaris.
16. ,, biceps.
17. ,, pulchella.
18. ,, ,, var. gracilis.
19. ,, ,, ,, acicularis.
20. ,, ,, ,, lanceolata.
21. ,, ,, ,, linearis.
22. ,, capitata.
23. ,, ,, var. longiceps.
24. ,, ulna.
25. ,, ,, var. oxrhynchus.
26. ,, ,, ,, amphirhynchus.
27. ,, longissima.
28. ,, obtusa.
29. ,, splendens.
30. ,, ,, var. radians.
31. ,, ,, ,, danica.
32. ,, salina.
33. ,, gallionii.
34. ,, spathulata.
35. ,, barbatula.
36. ,, tabulata.
37. ,, arcus.
38. ,, affinis.
39. ,, Nitzschiodes.
40. ,, Frauenfeldii.
41. ,, putealis.
42. ,, Smithii.
43. ,, debilis.

PLATE 29.

Fig. 1. Grammatophora marina, p. 315.
2. „ serpentina.
3. Tabellaria flocculosa, p. 317.
4. Tetracyclus lacustris, p. 318.
5. Rhabdonema arcuatum, p. 318.
6. Striatella unipunctata, p. 320.
7. Tessella interrupta, p. 320.
8. Amphipleura pellucida, p. 321.
9. Mastogloia convergens, p. 325.
10. „ Closeii.
11. „ portierana.
12. „ Smithii.
13. „ costata.
14. Dickieia ulvoides, p. 328.
15. Colletonema neglectum, p. 331.
16. Berkeleya fragilis, p. 331.
17. Schizonema crucigerum, p. 333.
18. „ Smithii.
19. „ Grevillii.
20. „ obtusum.
21. Diadesmis Williamsonii, p. 337.
22. Brebissonia Boeckii, p. 338.

PLATE 30.

Fig. 1. Navicula nobilis, p. 340.
2. „ cardinalis.
3. „ viridis.
4. „ alpina.
5. „ pachyptera.
6. „ distans.
7. „ undulata.
8. „ rectangulata.
9. „ Trevelyana.
10. „ oblonga.

11. Navicula longa.
12. ,, tabellaria.
13. ,, divergens var.
14. ,, borealis.
15. ,, menapiensis.
16. ,, clepsydra.
17. ,, rupestris.
18. ,, ceres.
19. ,, gibba.
20. ,, ,, var. Boeckii.
21. ,, ,, ,, parva.
22. ,, hemiptera.
23. ,, apiculata.
24. ,, Brebissonii.
25. ,, ,, var. angusta.
26. ,, nodosa.
26*a*. ,, ,, var. staurophora.
27. ,, icostauron.
28. ,, stauroptera.
29. ,, bacillum.
30. ,, Americana.
31. ,, isocephala.
32. ,, bicapitata.
33. ,, ,, var. crucifera.
34. ,, ,, ,, constricta.
35. ,, termes.
36. ,, microstauron.
37. ,, crucifera.
38. ,, pinnularia.
39. ,, scalaris.
40. ,, cuneata.
41. ,, acuminata.
42. ,, retusa.
43. ,, integra.
44. ,, pachycephala.
45. ,, subcapitata.
46. ,, gracillima.
47. ,, macula.
48. ,, zellensis.

PLATE 31.

Fig. 1. **Navicula cuspidata**, p. 357.
2. „ **fulva.**
3. „ **cuspis.**
4. „ **rhombica.**
5. „ **cœrulea.**
6. „ **decipiens.**
7. „ **tumens.**
8. „ **rostrata.**
9. „ **tenuirostris.**
10. „ **ambigua.**
11. „ **sphœrophora.**
12. „ **quarnerensis.**
13. „ **Davidsoniana.**
14. „ **ovulum.**
15. „ **latiuscula.**
16. „ **Barkeriana.**
17. „ **Grunovii.**
18. „ **amphisbæna.**
19. „ **elegans.**
20. „ **palbebralis.**
21. „ **hebes.**
22. „ **lineata.**
23. „ **liber.**
24. „ **lacuneata.**
25. „ **Gründleriana.**
26. „ **iridis.**
27. „ „ var. **amphigomphus.**
28. „ „ „ **affinis.**
29. „ dubia.
30. „ limosa.
31. „ „ var. truncata.
32. „ undosa.
33. „ esox.
34. „ trochus.
35. „ producta.

36. Navicula coccononeiformis.
37. ,, Kotzchyi.
38. ,, maxima.
39. ,, ,, var. linearis.
40. ,, subula.
41. ,, translucida.
42. ,, papillifera.
43. ,, liburnica.
44. ,, plumbicolor.
45. ,, veneta.
46. ,, Johnsonii.
47. ,, simulans.
48. ,, Delginensis.
49. ,, rhomboides.
50. ,, serians.
51. ,, crassinervia.
52. ,, dirhynchus.
53. ,, rostellum.
54. ,, lævissima.
55. ,, oblongella.
56. ,, incurva.

PLATE 32.

Fig. 1. Navicula punctulata, p. 377.
2. ,, granulata.
3. ,, humerosa.
4. ,, ,, var. fuscata.
5. ,, ,, ,, quadrata.
6. ,, latissima.
7. ,, meniscus.
8. ,, lucida.
9. ,, cluthensis.
9*a*. ,, ,, var. producta.
10. ,, punctata.
11. ,, lacustris.
12. ,, maculosa.

13. Navicula scutilloides.
14. ,, pusilla.
15. ,, tumida, var. linearis.
16. ,, pulchra.
17. ,, fusca.
18. ,, Smithii.
19. ,, Collisiana.
20. ,, æstiva.
21. ,, elliptica.
22. ,, ,, var. ovalis.
23. ,, clavata.
24. ,, Hennedyi.
25. ,, nebulosa.
26. ,, ,, var. suborbicularis.
27. ,, prætecta.
28. ,, Morei.
29. ,, Sandriana.
30. ,, Franciscæ.
31. ,, Hibernica.
32. ,, nitescens.
33. ,, Richardsoniana.
34. ,, Stokesiana.
35. ,, Wrightii.
36. ,, spectabilis, var.

PLATE 33.

Fig. 1. Navicula lyra, p. 391.
2. ,, ,, var. elliptica.
3. ,, ,, ,, Grunovii.
4. ,, ,, ,, minor.
5. ,, ,, ,, seductilis.
6. ,, ,, ,, constricta.
7. ,, pygmæa.
8. ,, ,, var. cuneata.
9. ,, expleta.
10. ,, cynthia.

11. Navicula sansegana.
12. ,, Arraniensis.
13. ,, Eugenia.
14. ,, scutellum.
15. ,, suborbicularis.
16. ,, ,, var. forficula.
17. ,, Schmidtii.
18. ,, coffeiformis.
19. ,, eudoxia.
20. ,, Donkiniana.
21. ,, marginata.
22. ,, subcivita.
23. ,, Archeriana.
24. ,, incurvata.
25. ,, musca.
26. ,, interrupta.
27. ,, apis.
28. ,, bombus.
29. ,, didyma.
30. ,, splendida.
31. ,, Gregorii.
32. ,, Williamsonii.
33. ,, incisa.
34. ,, crabro, var. denticulata.
35. ,, Pfitzeriana.
36. ,, Vickersii.

PLATE 34.

Fig. 1. Navicula directa, p. 406.
2. ,, exilis.
3. ,, radiosa.
4. ,, gracilis.
5. ,, acuta.
6. ,, peregrina.
7. ,, zostereti.

8. Navicula Cleviana.
9. ,, digito-radiata.
10. ,, Ergadensis.
11. ,, cyprinus.
12. ,, galvagensis.
13. ,, solaris.
14. ,, viridula.
15. ,, Heufleri.
16. ,, Northumbrica.
17. ,, arenaria.
18. ,, inflexa.
19. ,, Hungarica.
20. ,, Carassius.
21. ,, mutica.
22. ,, semen.
23. ,, inflata.
24. ,, Anglica.
25. ,, cryptocephala.
26. ,, angustata.
27. ,, Lagerstedtii.
28. ,, gastrum.
29. ,, binodis.
30. ,, dicephala.
31. ,, rhyncocephala.
32. ,, globifera.
33. ,, rostellifera.
34. ,, cancellata.
35. ,, minor.
36. ,, perpusilla.
37. ,, seminulum.

N. B.—All the figures in the preceding Plates of Diatoms are magnified 400 diameters, unless otherwise indicated.

Fig. 10, Plate 29.—The Striæ should be radiate.

PLATE 35.

ILLUSTRATIVE OF PROFESSOR EDW. PERCEVAL WRIGHT'S PAPER "ON A NEW GENUS AND SPECIES OF PANDARINA."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 583.

Fig. 1. Stasiotes Rhinodontis, gen. et sp. nov. Nat. size.
2. ,, dorsal aspect.
3. ,, side view.
4. ,, ventral aspect.
5. ,, anterior antenna × 25.
6. ,, rostrum and palpi (*a*) × 25.
rostrum (*b*) × 50.
,, shewing toothing (*c*) + 200.
7. ,, posterior antenna × 25.
8. ,, first foot-jaw × 25: chelæ (*a*) × 50.
9. ,, second ,, ,,
10. ,, first abdominal foot × 25.
11. ,, second ,, ,,
12. ,, third ,, ,,
13. ,, fourth ,, ,,
14. ,, last segment with appendages.

PLATE 36.

ILLUSTRATIVE OF DR. KELLY'S PAPER "ON A CASE OF POLYDACTYLISM."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 539.

Fig. 1. I., II., III., IV., V., VI. The metacarpal bones.
P. I., P. II., P. III. First, second, and third Pollices.
a, Posterior angle of Os Triquetrum.
b, Interosseous ligament, corresponding with the line of junction of the "Complemental process," with the Scaphoid in the left hand (fig. 2, *b*).
c, Line of fusion between the Posterior Trapezoid and the Complemental process.
d, The depression indicating the tendency to bifidity in the second metacarpal bone.

Fig. 2. P. I., P. II., P. III. First, second, and third Pollices.
a, Posterior angle of Os Triquetrum.
b, Line of union between the Scaphoid and the "Complemental process."
c, The cartilaginous ferule on apex of the metacarpal bone of first Pollex.
d, Sesamoid bones.
e, The united second and third phalanges of third Pollex.

Fig. 3. *a*, Anterior Trapezoid.
b, Broken line indicating the position of the Os Triquetrum.

Fig. 4. The Os Triquetrum of right hand.

Fig. 5. The two bones in the left hand corresponding with the Os Triquetrum of the right hand.
a, The detached unciform process.

PLATE 37.

ILLUSTRATIVE OF DR. KELLY'S PAPER "ON A CASE OF POLYDACTYLISM."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 539.

Fig. 6. 1, Opponens Pollicis.
2, Abductor Pollicis.
3, The deeper and only head of the Flexor Brevis Pollicis, dividing into two slips.
4, 4, 4, The three divisions of the Interpollicaris.
5, Flexor Pollicis Secundi et Tertii.
6, Musculus Accessorius ad Lumbricalem Primum.
7, Adductor Pollicis.
8, Musculus Accessorius ad Transversum Manum.
9, Transversus Manus.

Fig. 7. 1, Opponens Pollicis.
2, 2, 2, The three slips of the Abductor Pollicis.
3, 3, 3, The three portions of the Flexor Brevis Pollicis.
4, The two portions of the Interpollicaris.
5, Musculus Accessorius ad Transversum Manum.
6, Adductor Pollicis.
7, Lumbricalis ad Pollicem Tertium.

PLATES 38 & 39.

ILLUSTRATIVE OF DR. KELLY'S PAPER "ON A CASE OF POLYDACTYLISM."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 539.

Plate 38, Fig. 8. 1, 2, Extensor Ossis Metacarpi Pollicis; two slips (the second Extensor Internodii Pollicis Primi).
3, Extensor Primi Internodii Pollicis.
4, Extensor Secundi Internodii Pollicis.
5, Slip between Extensor Communis Digitorum and Extensor Indicis.
6, Aponeurotic web between the first and second Pollex, into the free margin of which were inserted some of the muscles of the anterior group.

Fig. 9. 1, 2, 3, Three slips of Extensor Ossis Metacarpi Pollicis.
4, Extensor Primi Internodii Pollicis.
5, 6, Two slips of Extensor Secundi Internodii Pollicis.
7, Aponeurotic web.
8, Extensor Indicis.

Plate 39, Fig. 10. The vessels and nerves of the anterior surface of right hand.

Fig. 11. Ditto, of the left hand.
1, The great Arteria Medinna.

PLATE 40.

Illustrative of Dr. Perceval Wright's Paper "On a New Genus and Species of Sponge."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 754.

Fig. 1. Kalispongia Archeri, gen. et spec. nov., × 50 (side view).
2. ,, ,, front view of head portion, × 50, of another specimen.
3. ,, ,, stem portion of an apparent variety, × 50.
4. ,, ,, portion of tissue of stem, × 250.
5. ,, ,, ,, ,, of head, × 250.

PLATE 41.

ILLUSTRATIVE OF MR. HARDMAN'S PAPER "ON THE IRISH CARBONIFEROUS DOLOMITES."

Vide Proceedings of R. I. Acad., Vol. 2, Ser. 2, p. 705.

Fig. 1. Rockhead Quarry, Loughry, Co. Tyrone.

2. Section at Riverview, Co. Kilkenny.

a, *a*, *a*. Dark grey limestone.

b, *b*, *b*. Intervening layers of calcite.

3. Dolomite, near Jenkinstown, Co. Kilkenny, showing cellular structure simulating "current bedding," the cavities filled with calc-spar.

PLATE 42.

ILLUSTRATIVE OF MR. HARDMAN'S PAPER "ON THE IRISH CARBONIFEROUS DOLOMITES."

Fig. 4. Plan of limestones and dolomites, Ballyfoyle, Kilkenny.
5. Section at Ballyfoyle, showing limestone passing into dolomite.
6. Enlarged section at (*a*), fig. 6, showing passage of limestone into dolomite.

PLATE 43.

ILLUSTRATIVE OF DR. MOORE'S PAPER "ON IRISH HEPATICÆ."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 591.

Fig. 1. Lejeunea patens, Lindberg; natural size.
2. ,, ,, × 15.
3. ,, ,, × 30.
7. ,, leaf and portion of stem, × 100.
8. ,, amphigastrium, × 100.
9. ,, portion of leaf, mag. × 400.
Drawn from specimen supplied by Dr. Lindberg.
4. ,, dorsal aspect of plant, with colesule and male amentulæ, × 25.
5. ,, branch, with colesule, × 50.
6. ,, ventral aspect of plant, with male amentulæ.

Drawn from plant collected at Glenad, Co. Leitrim, 1875.

PLATE 44.

ILLUSTRATIVE OF DR. MOORE'S PAPER "ON IRISH HEPATICÆ."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 591.

Fig. 1. Lejeunea Moorei, Lindberg; natural size.
2. ,, ,, × 10.
3. ,, ventral aspect of plant, showing colesules and male amentulæ, × 25.
4. ,, leaf and portion of stem, × 50.
5. ,, amphigastrium, × 100.
6. ,, portion of leaf, × 400.

PLATE 45.

Illustrative of Dr. Moore's Paper "On Irish Hepaticæ."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 591.

Fig. 1. **Frullania Hutchinsiæ, β integrifolia, Nees; natural size.**
2. " " × 10, with male amentulæ and colesules.
3. " leaves and portion of stem, × 25.
4. " amphigastrium, × 75.
5. " portion of leaf, × 400.
6 & 7. " portion of stem, leaves and amphigastrium of typical form of *a*. after Hooker.

PLATE 46.

ILLUSTRATIVE OF DR. M'NAB'S PAPER "ON A REVISION OF THE SPECIES OF ABIES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 673.

In the Description of Plates 46, 47, 48, and 49, all the figures are magnified 20 diameters. The letters refer to all the figures—e. Epidermis. h. Hypoderma. c. Resin-canals. s. Sheath of the fibro-vascular bundles.

Fig. 1. Abies bracteata. From specimen cultivated at Elvaston Nurseries, Borrowash, Derby.

2. ,, religiosa. From specimen cultivated at Castle Kennedy, N. B.

3. ,, amabilis. From a graft, from Douglass's plant, cultivated in the Royal Botanic Garden, Edinburgh.

3*a*. ,, amabilis. Near Lake Chilukweyak B. C.; Cascade Mountains, 49° N. lat., Dr. Lyall, 1859: Kew Herbarium.

4. ,, grandis. From a layer, from Douglass's plant, cultivated in the Royal Botanic Garden, Edinburgh.

4*a*. ,, grandis. From a specimen raised from Jeffrey's seeds, and cultivated in the Royal Botanic Garden, Edinburgh, as A. lasiocarpa.

5. ,, Lowiana. From a specimen raised from Jeffrey's seeds, and cultivated in the Royal Botanic Garden, Edinburgh.

6. ,, concolor. From Kew Herbarium: Fendler, "Pl. Novo-Mexicano," No. 828, 1847.

7. ,, lasiocarpa. From Kew Herbarium, "sp. typica," coll. Douglas.

7*a*. ,, lasiocarpa. From Kew Herbarium, unnamed specimen, marked "America Boreali-occidentalis," D. Douglas.

PLATE 47.

ILLUSTRATIVE OF DR. M'NAB'S PAPER "ON A REVISION OF THE SPECIES OF ABIES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 673.

Fig. 8. Abies lasiocarpa. Sent by Mr. Syme as Abies bifolia, A. Murray; collected by M. Roegl.

9. ,, lasiocarpa. East side of Cascade Mountains, 49° N. lat., Aug. 1860; Kew Herbarium; Colville, Indian name "Marcilp."

10. ,, Fraseri. From specimen cultivated at Castle Kennedy, N. B.

11. ,, balsamea. From specimen cultivated in the Royal Botanic Garden, Edinburgh.

12. ,, sibirica. From a plant cultivated in Glasnevin Garden, Dublin.

13. ,, Veitchii. Kew Herbarium.

14. ,, firma. Kew Herbarium: "Japonia, Nippon. 1864, Maximiowicz."

15. ,, bifida. From a specimen cultivated by Messrs. Veitch and Son, of Chelsea, and sent under the erroneous name of A. firma.

16. ,, n. sp. Harryana. From a specimen cultivated by Messrs. Veitch and Son, of Chelsea, and sent under the erroneous name of A. Veitchii.

17. ,, Pindrow. From a specimen cultivated in Glasnevin Garden, Dublin.

PLATE 48.

ILLUSTRATIVE OF DR. M'NAB'S PAPER "ON A REVISION OF THE SPECIES OF ABIES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 673.

Fig. 18. Abies Webbiana. From a specimen cultivated in Glasnevin Garden, Dublin.

19. ,, sp. Herbarium, Trinity College, Dublin: "Abies Webbiana, Himalaya occid., 9000 to 12,000, Hook, fil. et Thomson."

20. ,, pectinata. From a specimen cultivated in Glasnevin Garden, Dublin.

21. ,, pectinata, var. Mooreana. From a specimen cultivated in Glasnevin Garden, Dublin.

22. ,, Nordmanniana. From a specimen cultivated in Glasnevin Garden, Dublin.

23. ,, cilicica. Herbarium, Trinity College, Dublin: Kotschy, No. 370, "in regionibus Daniæ, *supra* Eden, alt. 5000. Die 28 Jul. 1855."

24. ,, cephalonica. From a specimen cultivated in Glasnevin Garden, Dublin.

25. ,, cephalonica, var. Apollinis. From a specimen cultivated in the Royal Botanic Garden, Edinburgh.

26. ,, Pinsapo. From a specimen cultivated in Glasnevin Garden, Dublin.

27. ,, Baborensis. From a specimen cultivated in Elvaston Nurseries, Borrowash, Derby.

PLATE 49.

ILLUSTRATIVE OF DR. M'NAB'S PAPER "ON A REVISION OF THE SPECIES OF ABIES."

Vide Proceedings R. I. Acad., Vol. 2, Ser. 2, p. 673.

Fig. 28. Abies sp. Drummond. From a specimen cultivated in the Royal Botanic Garden, Edinburgh.

29. Pseudotsuga nobilis. From a plant cultivated in the Royal Botanic Garden, Edinburgh.

29*a*. ,, nobilis. From a plant cultivated in the Royal Botanic Garden, Edinburgh, and sent under the erroneous name of A. amabilis of Douglas.

29*b*. ,, nobilis. Leaves from Kew Herbarium of the typė specimen of P. amabilis, Sabine, Douglas, sent by Professor Oliver, F. R. S.

30. ,, magnifica. From a plant cultivated by Mr. Anthony Waterer, Knap Hill Nursery, near Woking, Surrey.

30*a*. ,, magnifica. Kew Herbarium: "441. 150–200 ft. Sierra Nevada, L. California. W. Lobb."

31. ,, Fortunei. From a plant cultivated by Messrs. Veitch and Son, Chelsea, and forwarded under the name of Abies Jezoensis.

32. ,, Douglasii. From a plant cultivated in Elvaston Nurseries, Borrowash, Derby.

32*a*. ,, Douglasii. Kew Herbarium: "Rocky Mountain, Independence Bluff. Nuttall."

32*b*. ,, Douglasii. Herbarium, Trinity College, Dublin: New Mexico, Fendler, No. 829.

Fig. 2.

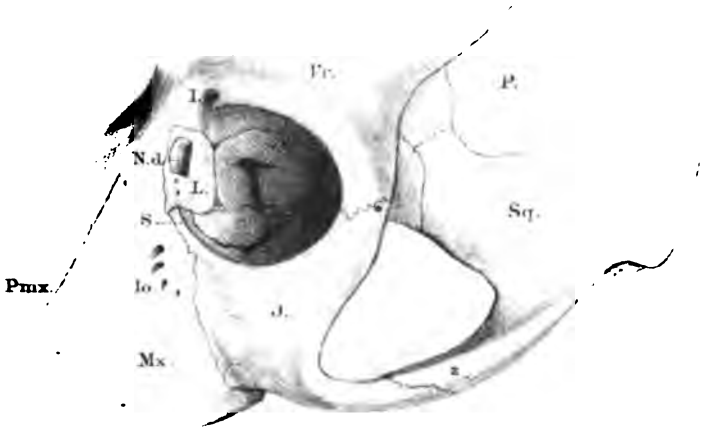
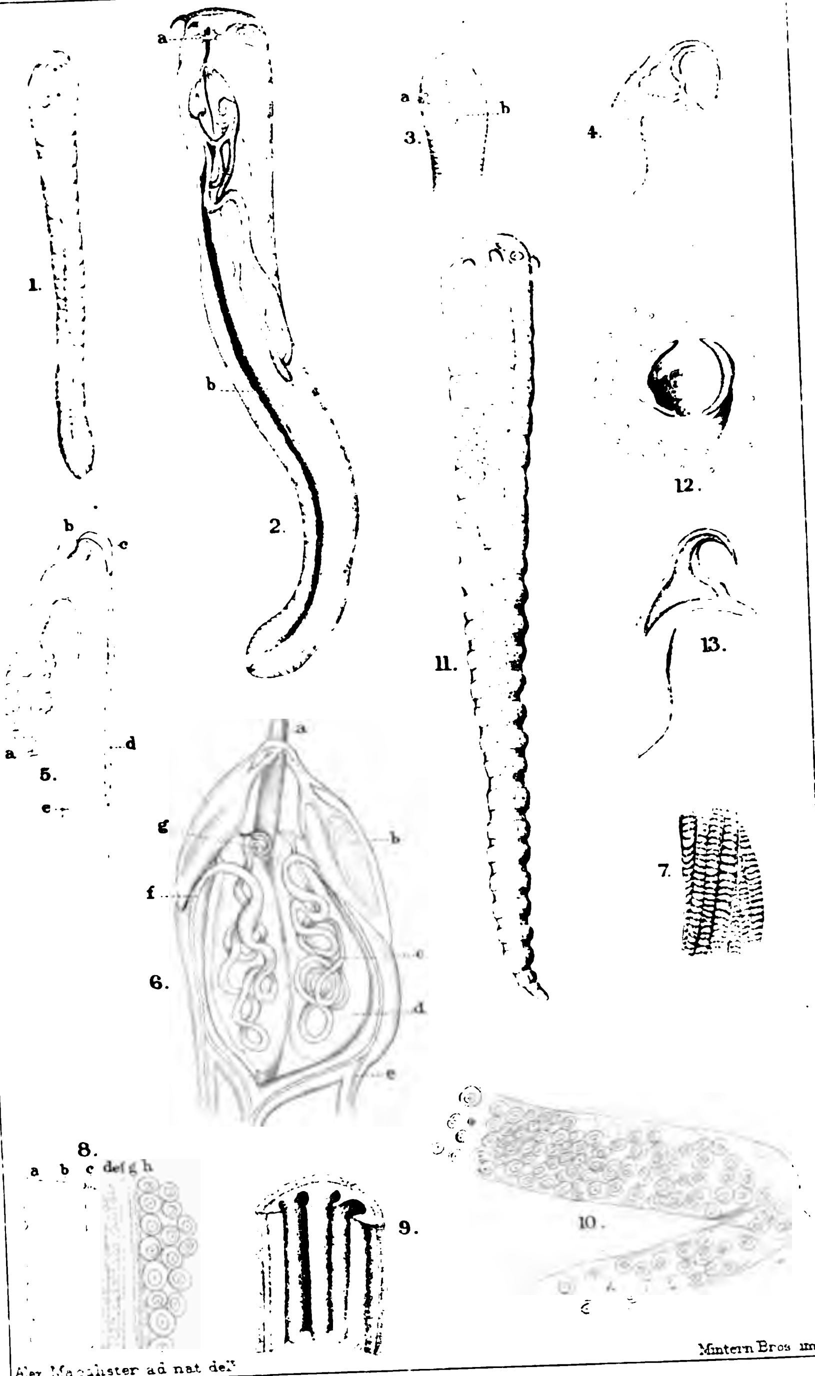


Fig. 1.

Alex Macalister ad nat del. Mintern Bros imp.

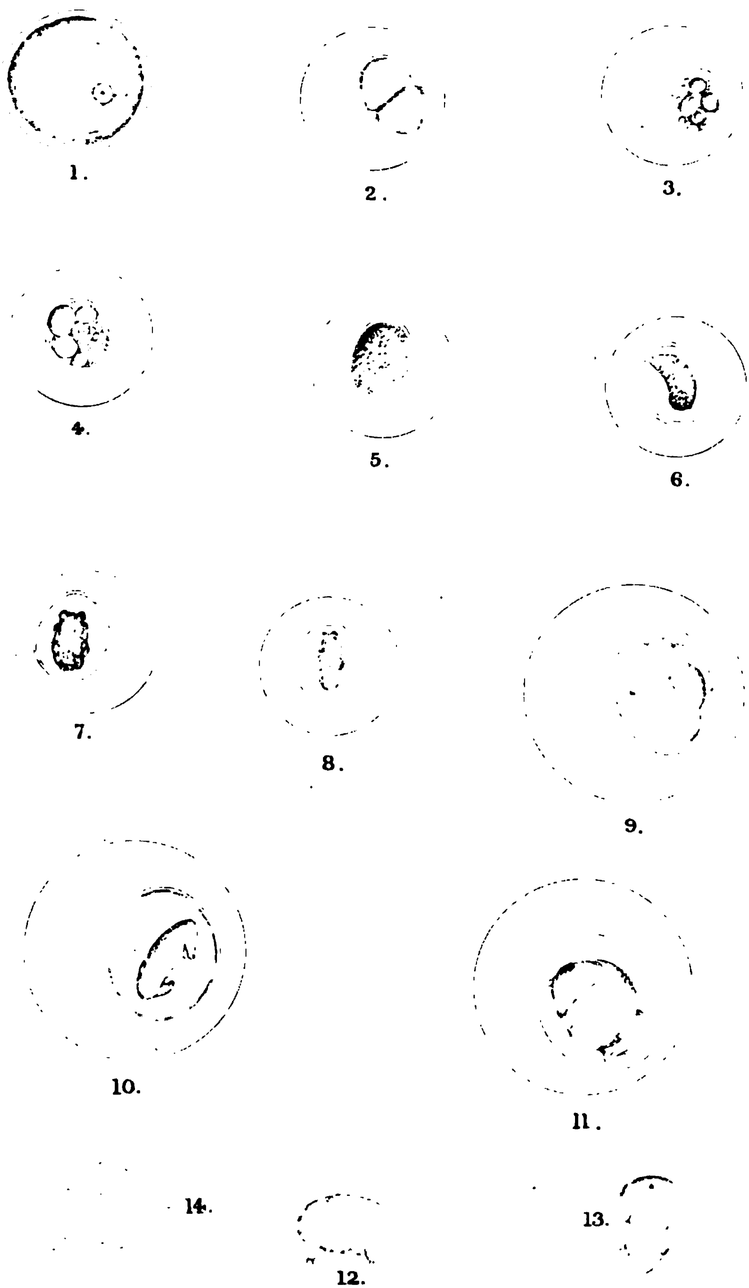
Lachrymo-jugal Suture.



Alex Macalister ad nat del.

Mintern Bros imp

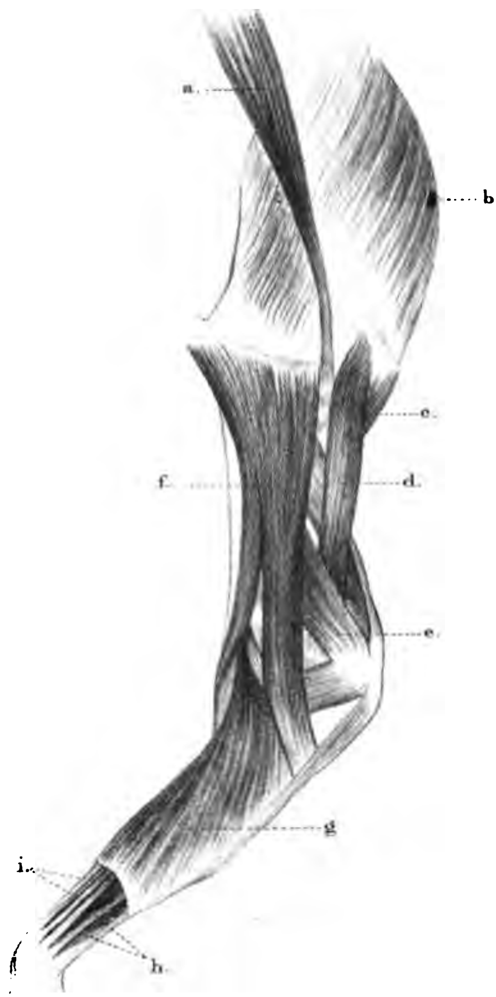
Pentastoma



Alex Macalister ad nat del[t]

Mintern Bros imp.

Pentastoma.



Alex Macalister ad nat del[t] Mintern Bros imp.

Cholœpus didactylus.

Fig. 1.

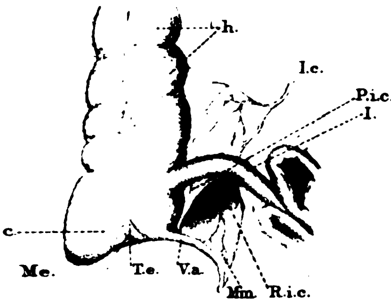


Fig. 2.

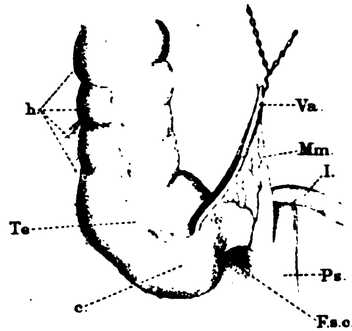
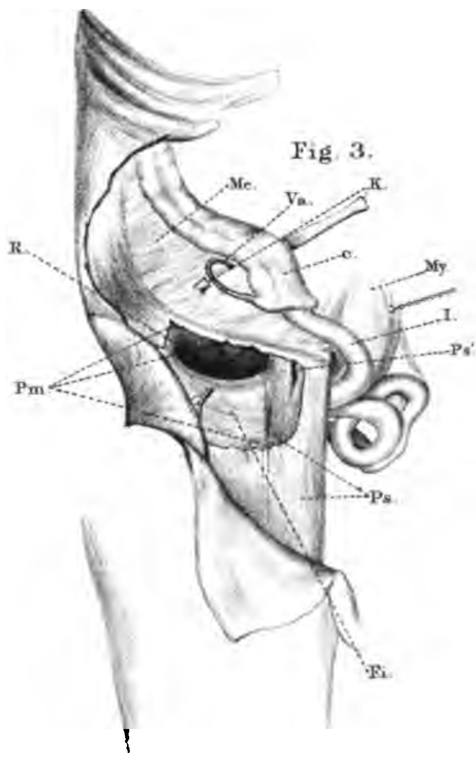
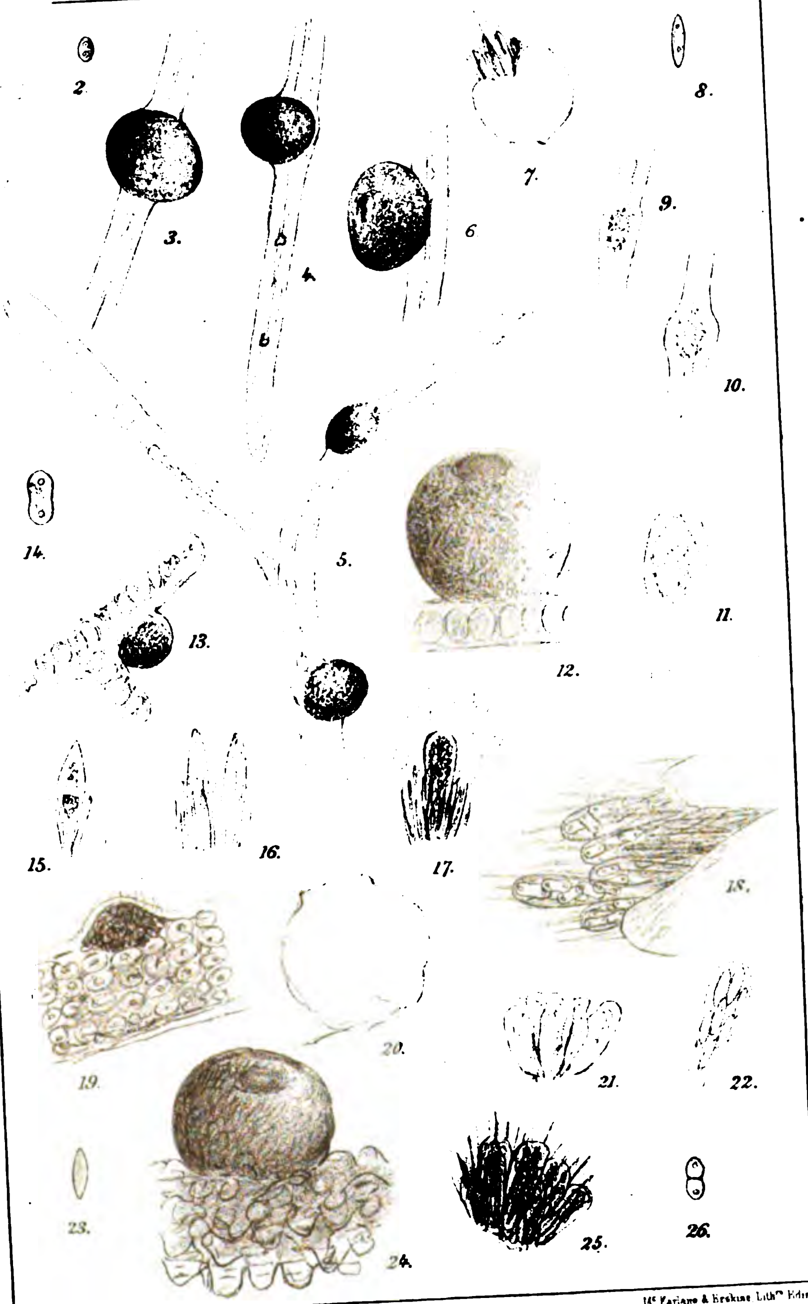


Fig. 3.



Alex. Macalister ad nat. delt. Mintern Bros imp.

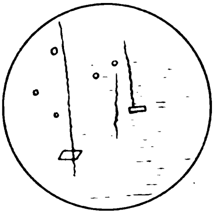
Retro-peritoneal Cavities.



W Archer, del[t]

M[c] Farlane & Erskine Lith[rs] Edin[r]

1.



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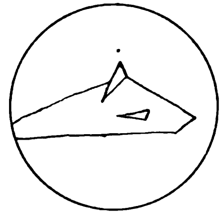

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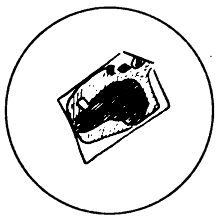

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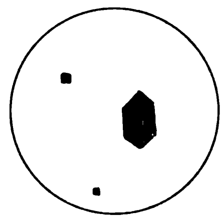

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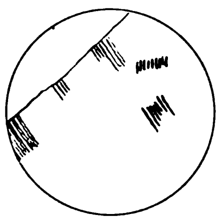


8.

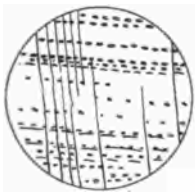
9.

10.

12.

G H K & G H Ford. Mintern Bros imp.

13.



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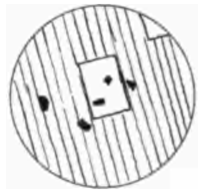

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16.

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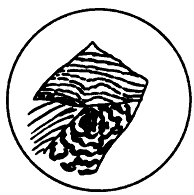

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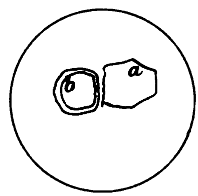

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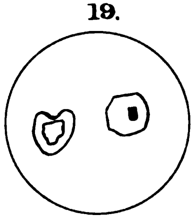

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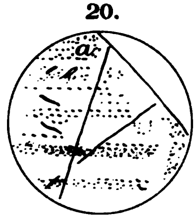

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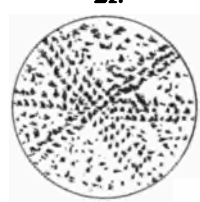

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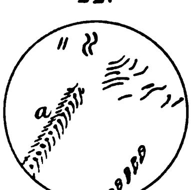

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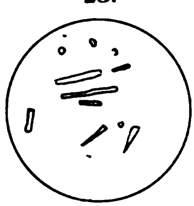

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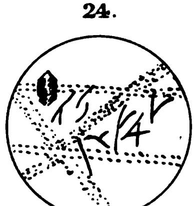
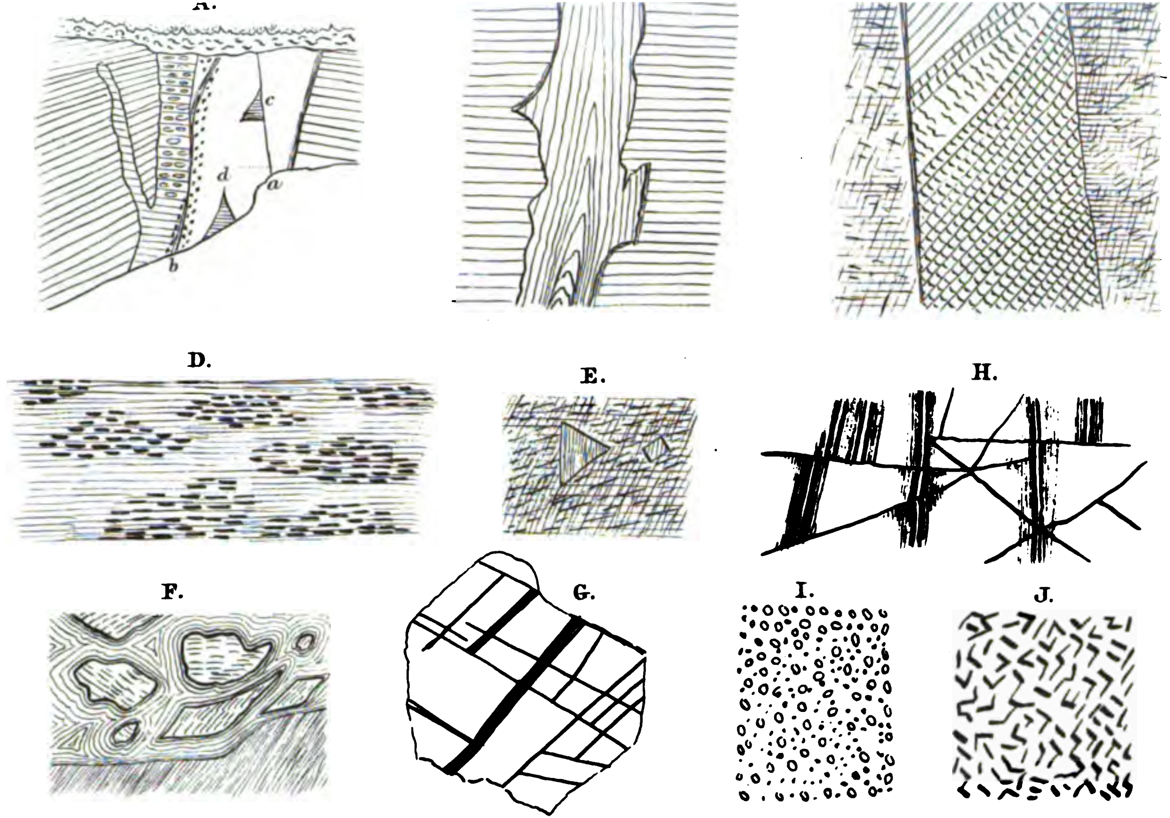


G.H.K & G.H.Ford.
Mintern Bros. imp.

A.



D.

E.

H.

F.

G.

I.

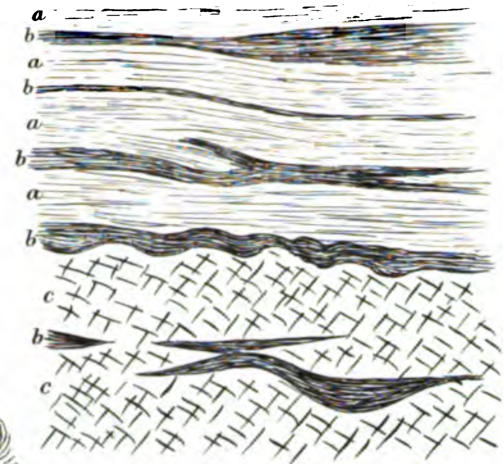
J.

G.H.K. & G.H Ford.

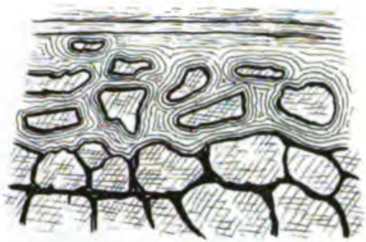
Mintern Bros imp

K.

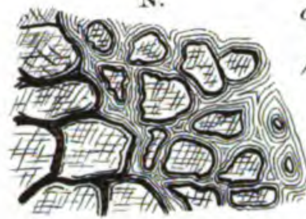
L.



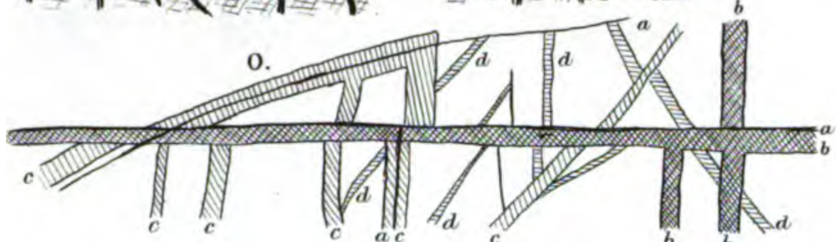
M.



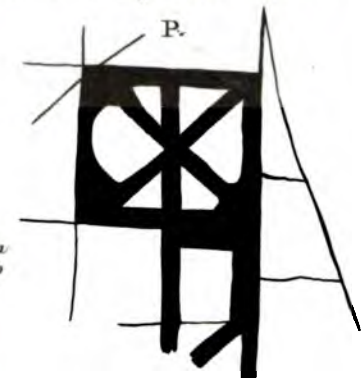
N.



O.

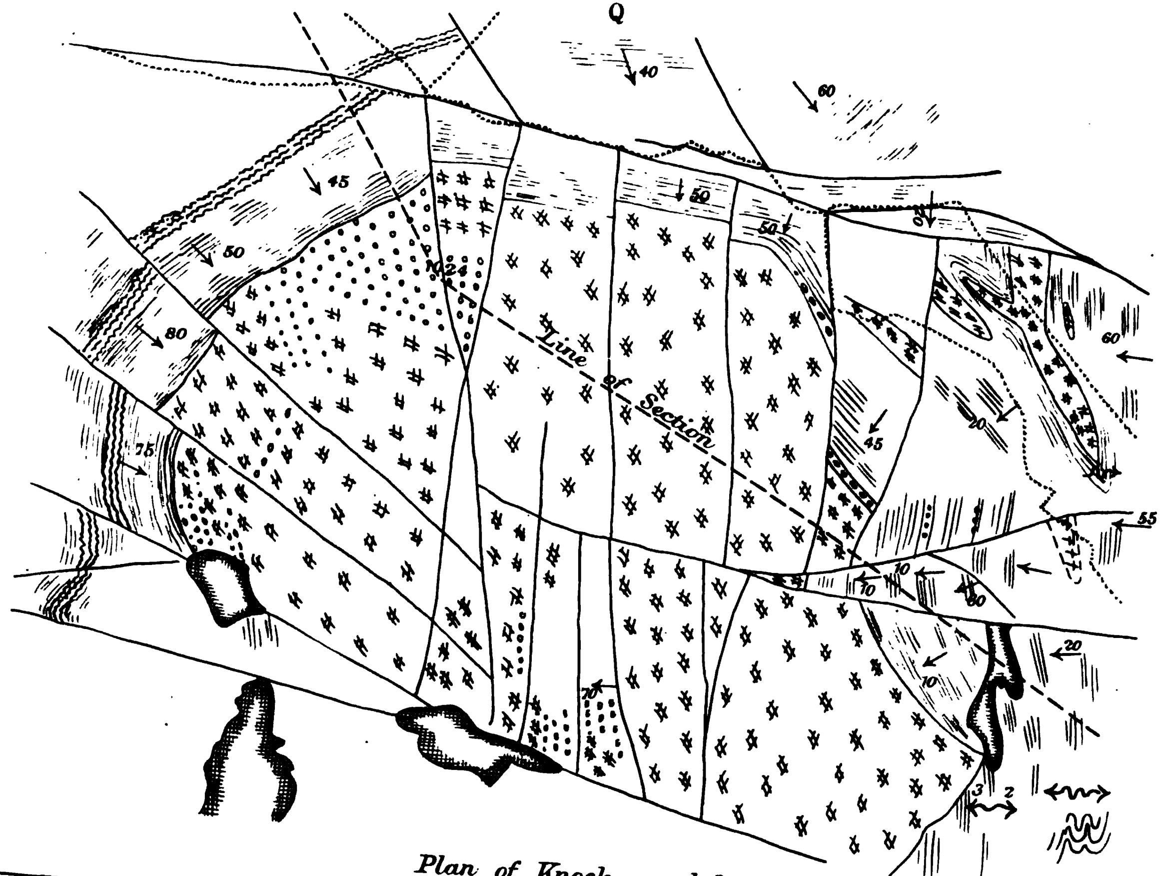


P.



G.H.K. & G.H. Ford

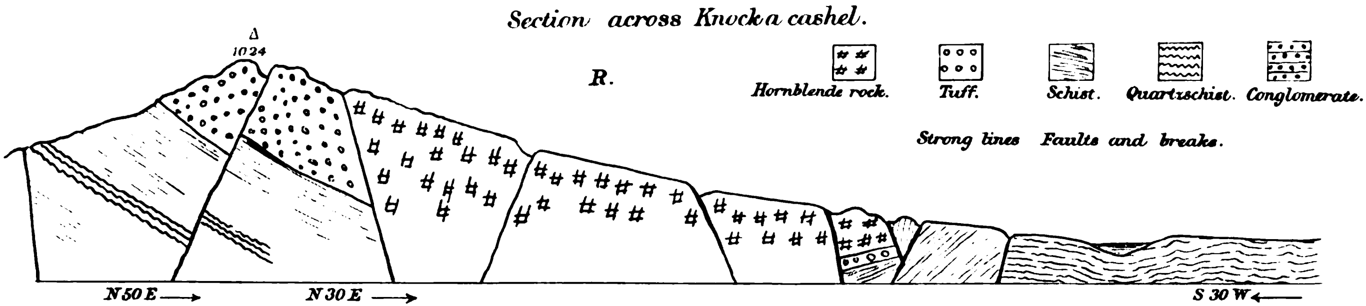
Mintern Bros. imp.

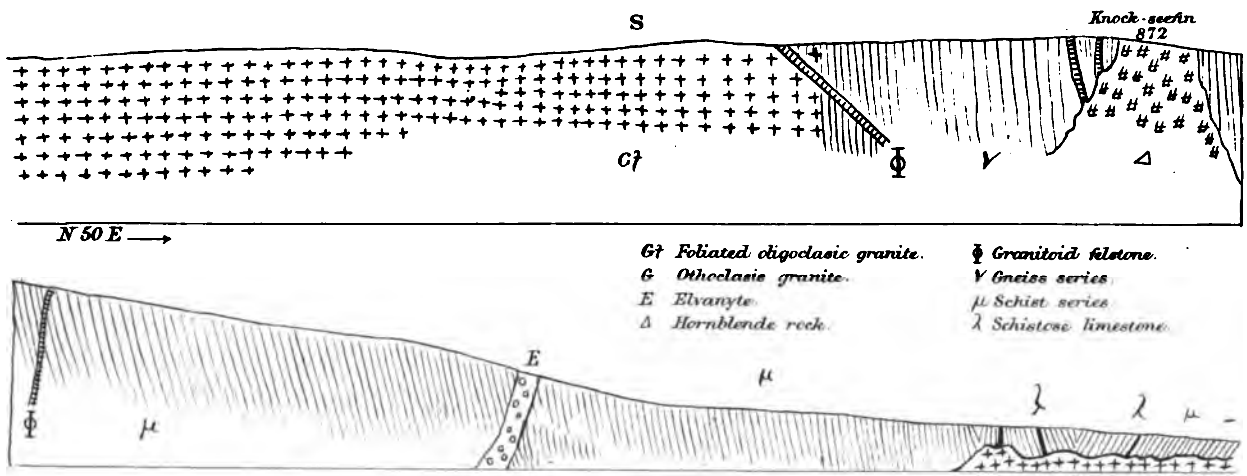


& G H. Ford.

Plan of Knock-a-cashel.

Scale 5 Inches to 1 Mile.





Section across Knock-seefin.

o H K & G.H Ford.

Scale, Plan 5, Sections 6 Inches to 1 Mile.

Mintern Bros. imp.

Fig. 1.

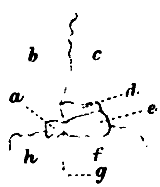


Fig. 3.

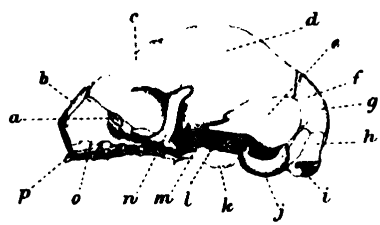


Fig. 2.

Fig. 5.

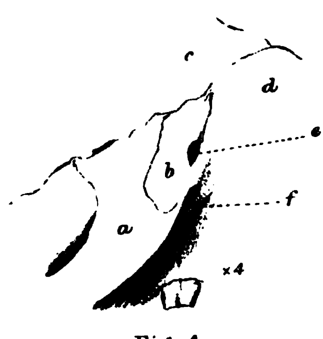
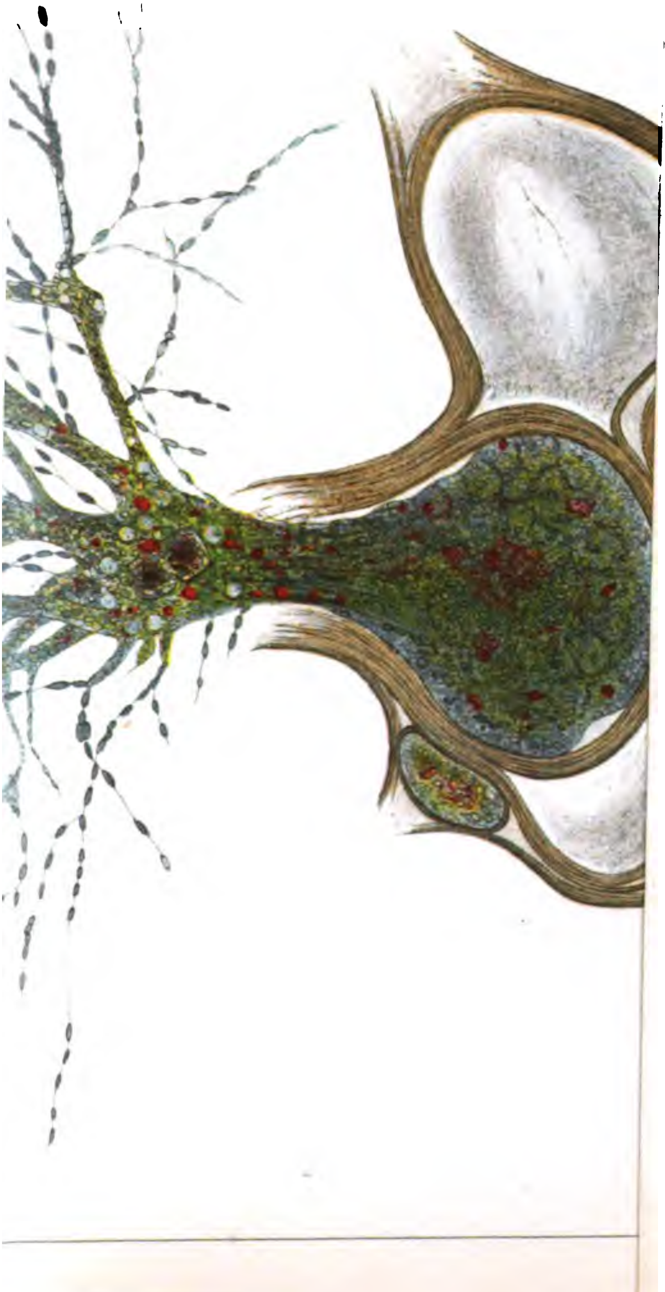
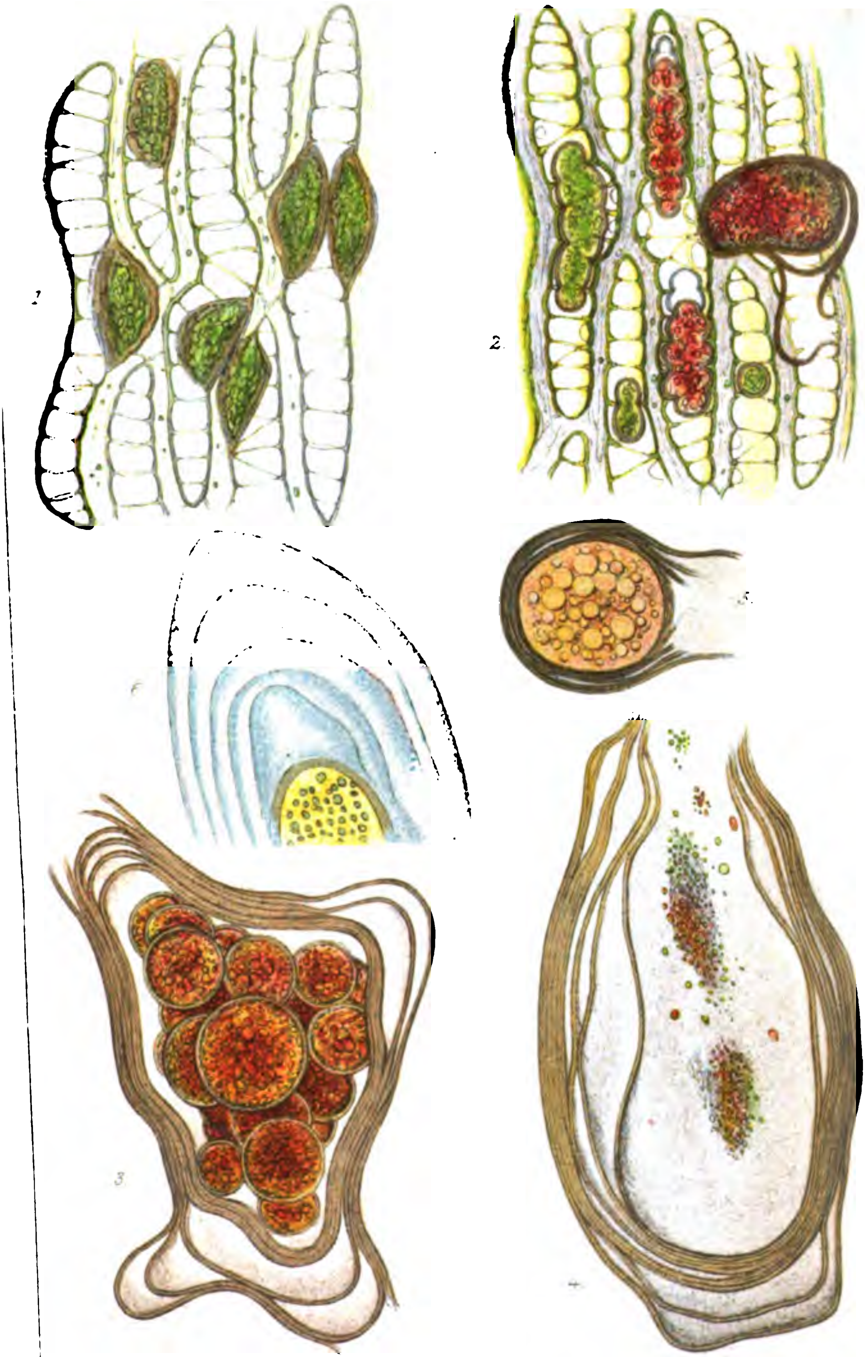


Fig. 4.

A.M. ad nat. G.H. Ford lith. Mintern Bros.

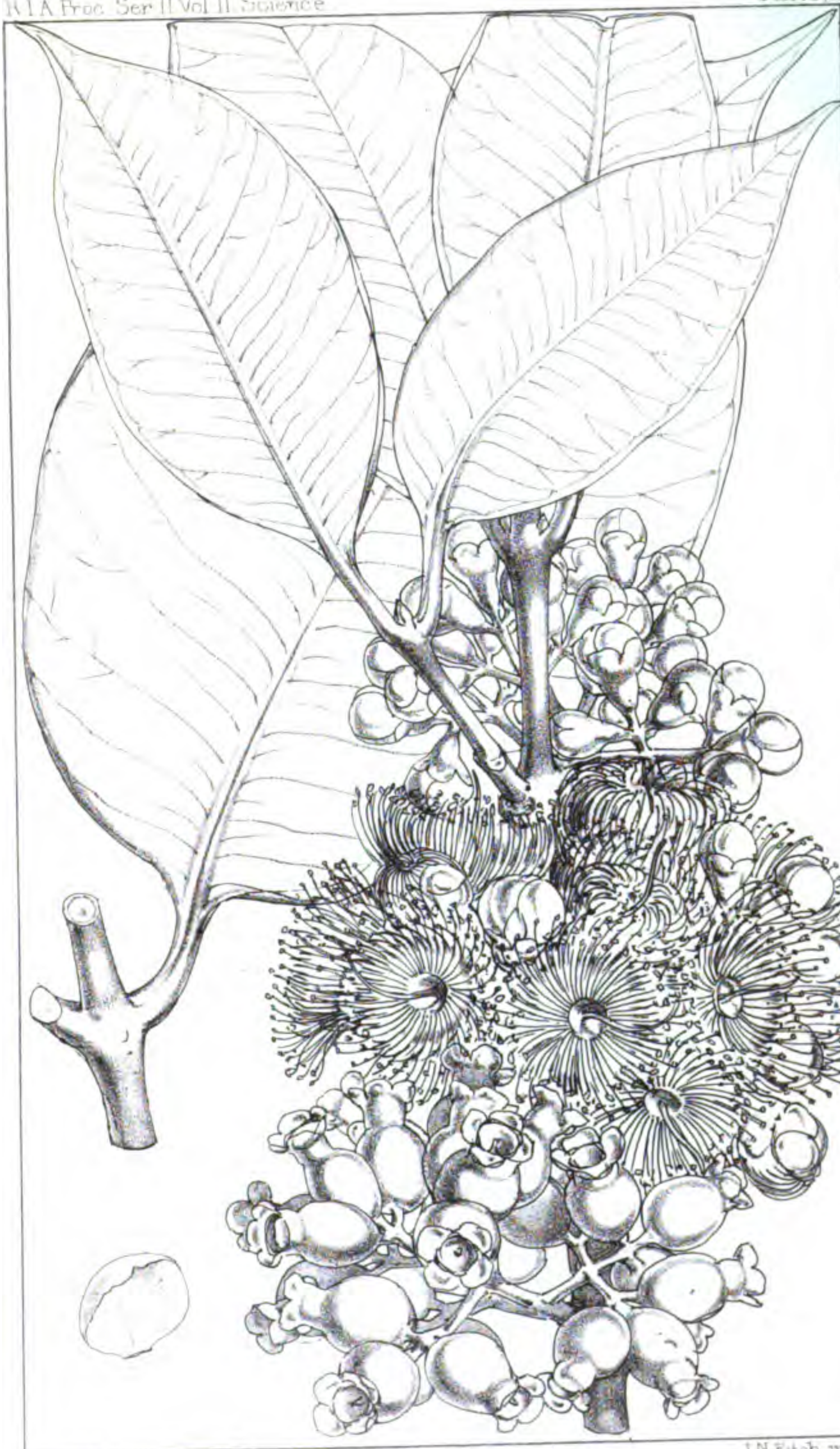
Bradypus gularis.





W. Archer ad nat. del.

McFarlane & Erskine Lith. Edin.



del. et lith. J.N. Fitch, imp.

Eugenia Wrightii *Baker*

W.H. Fitch del. et lith. J.N. Fitch imp.

Eugenia Sechellarum, *Baker*

Fig. 2. The 'Market Cross' Stalactitic Pillar.

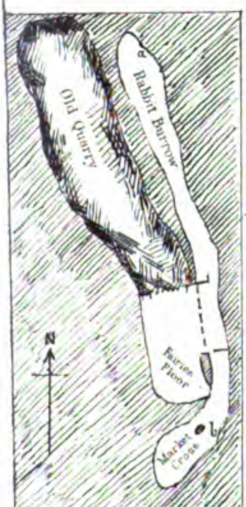


Fig. 1. Plan of Cave.

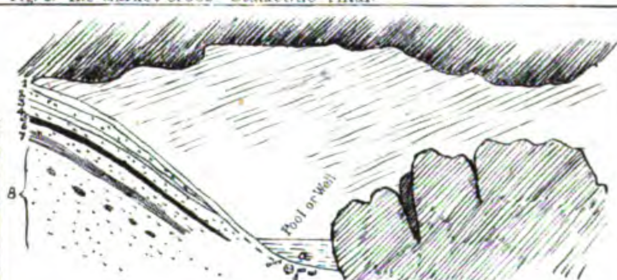


Fig. 3.

Fig. 4.

Fig. 5.

Edward T. Hardman del. et lith.

Forster & Co Lith. Dublin.

Cave of Dunmore, Co. Kilkenny.

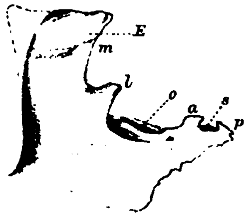


Fig. 1.

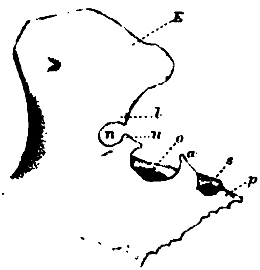


Fig. 2.

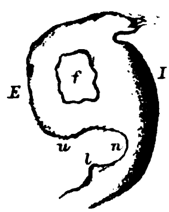
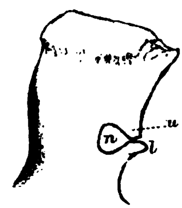


Fig. 3.



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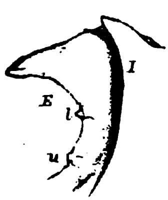

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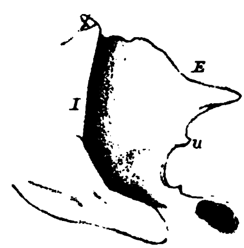
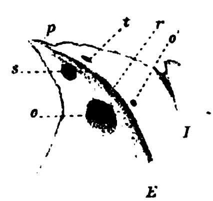


Fig. 6.

Fig. 7.



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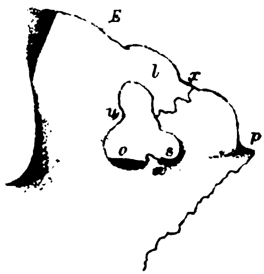

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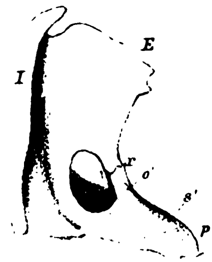


Fig. 10.

Fig. 12.

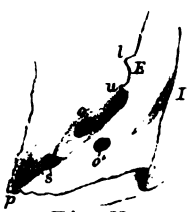
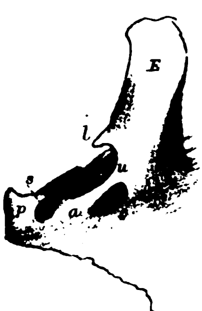


Fig. 11.

Fig. 14.



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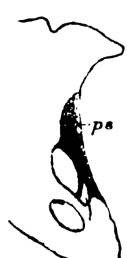


Fig. 15.

A. M. ad nat. del. G H Ford lith Mintern Bros imp

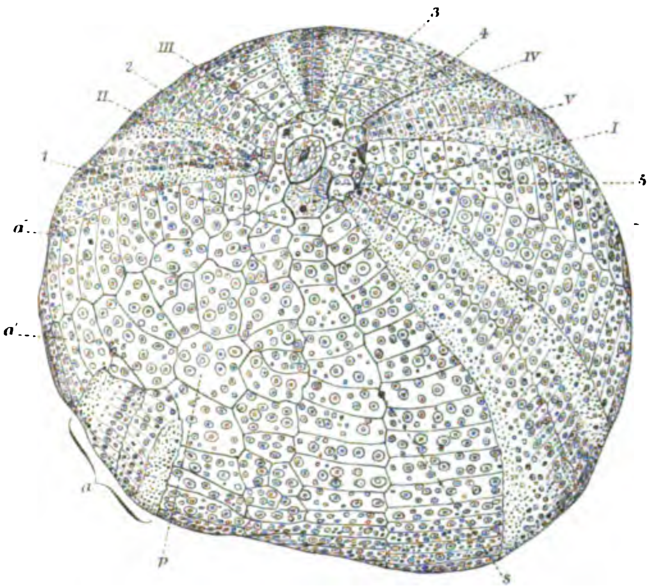
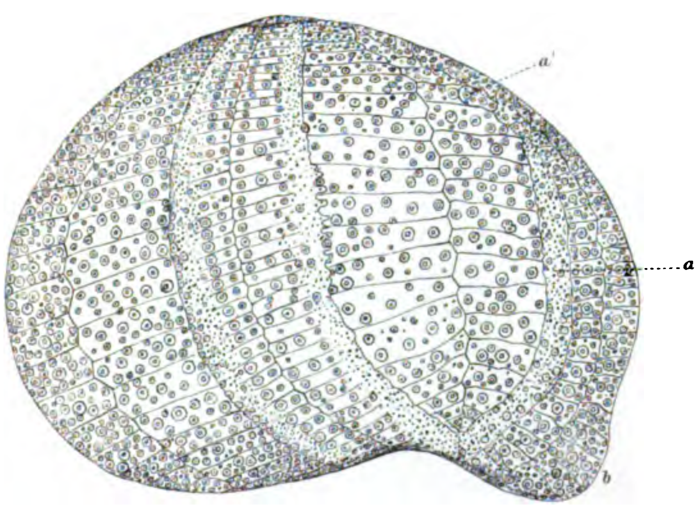


Fig. 1.



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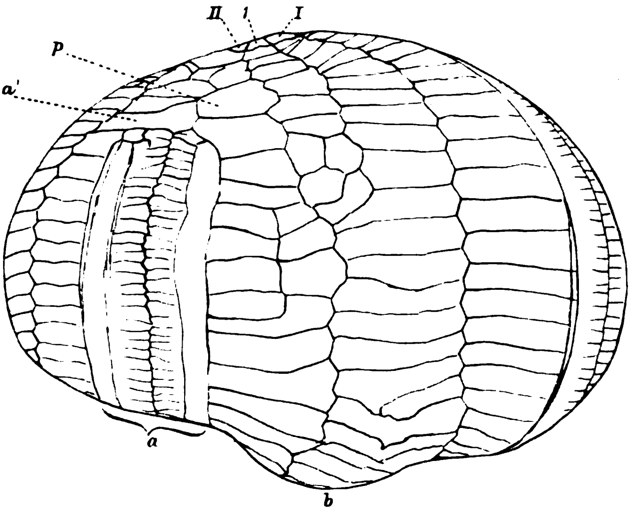

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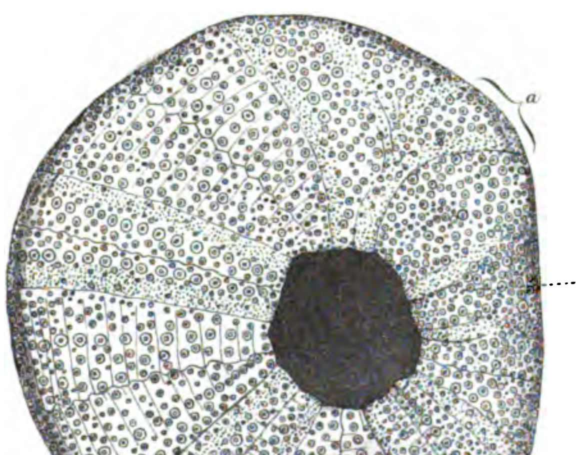
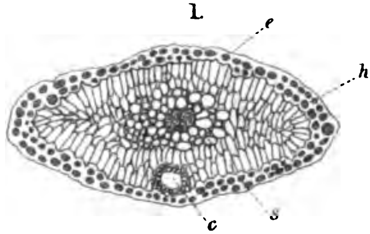


Fig. 4.

× 5/8 quam prox.

1.



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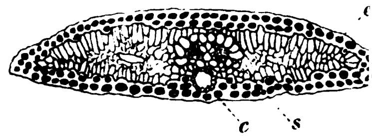

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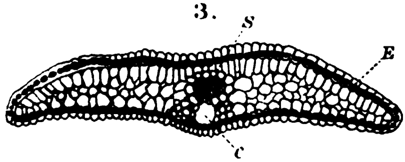

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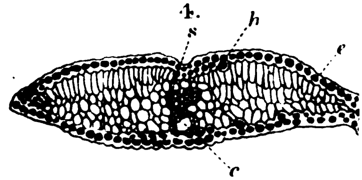

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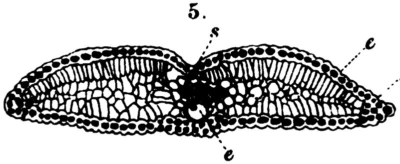

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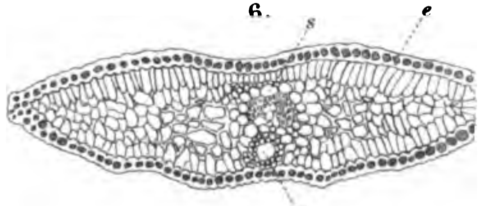
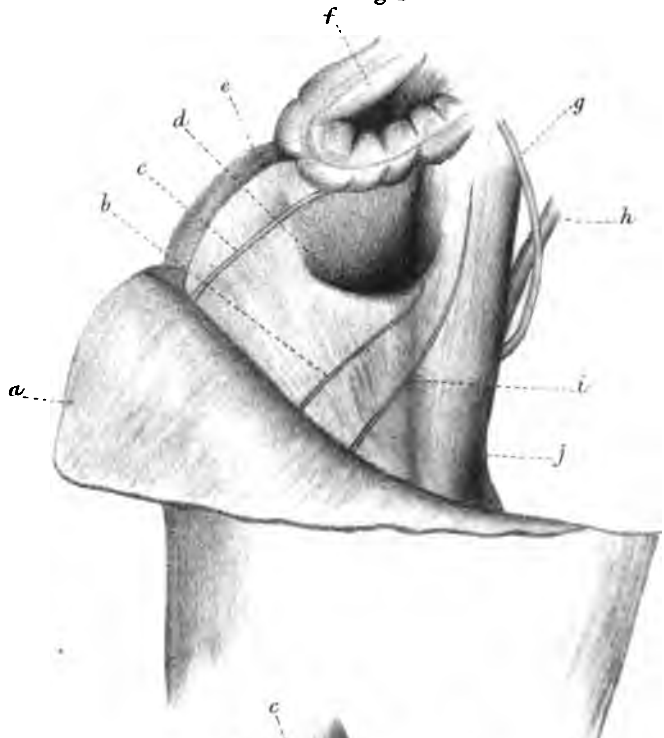


H.O. Hara C.E. del. G.H. Ford lith. Minte

Fig. 1.



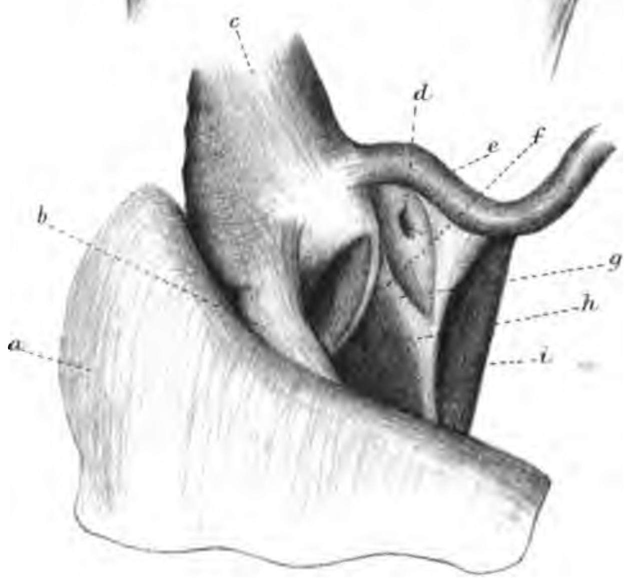


Fig. 2.

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Mintern Bros imp

Perityphlic Pouches

Fig. 1.

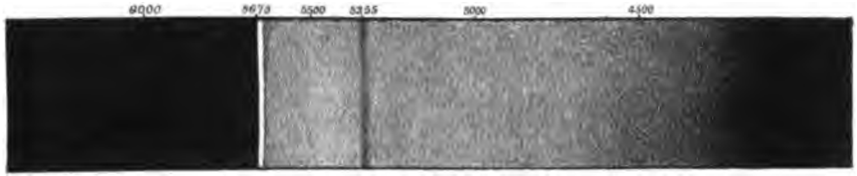

Fig. 2.

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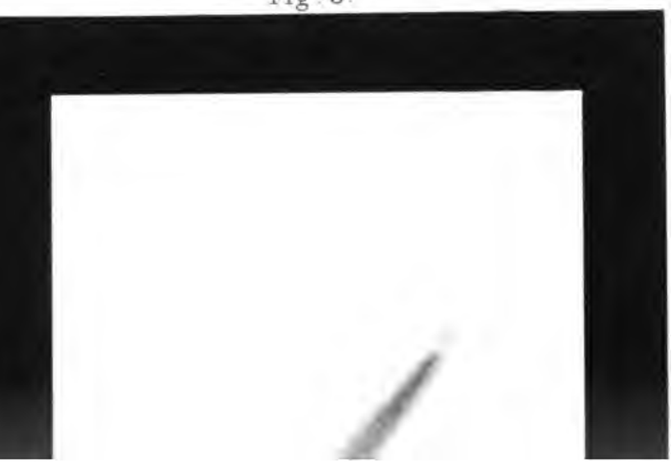

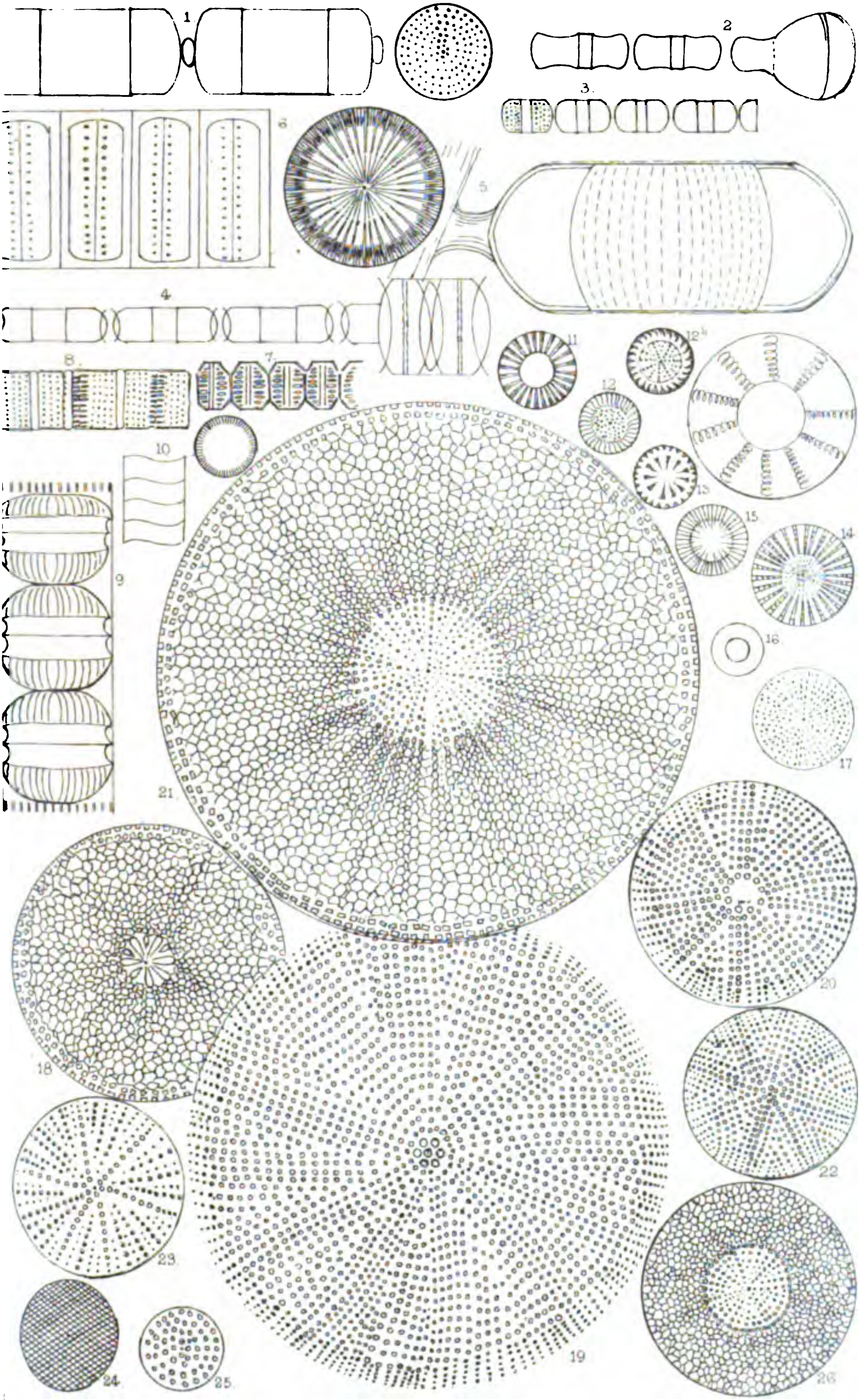

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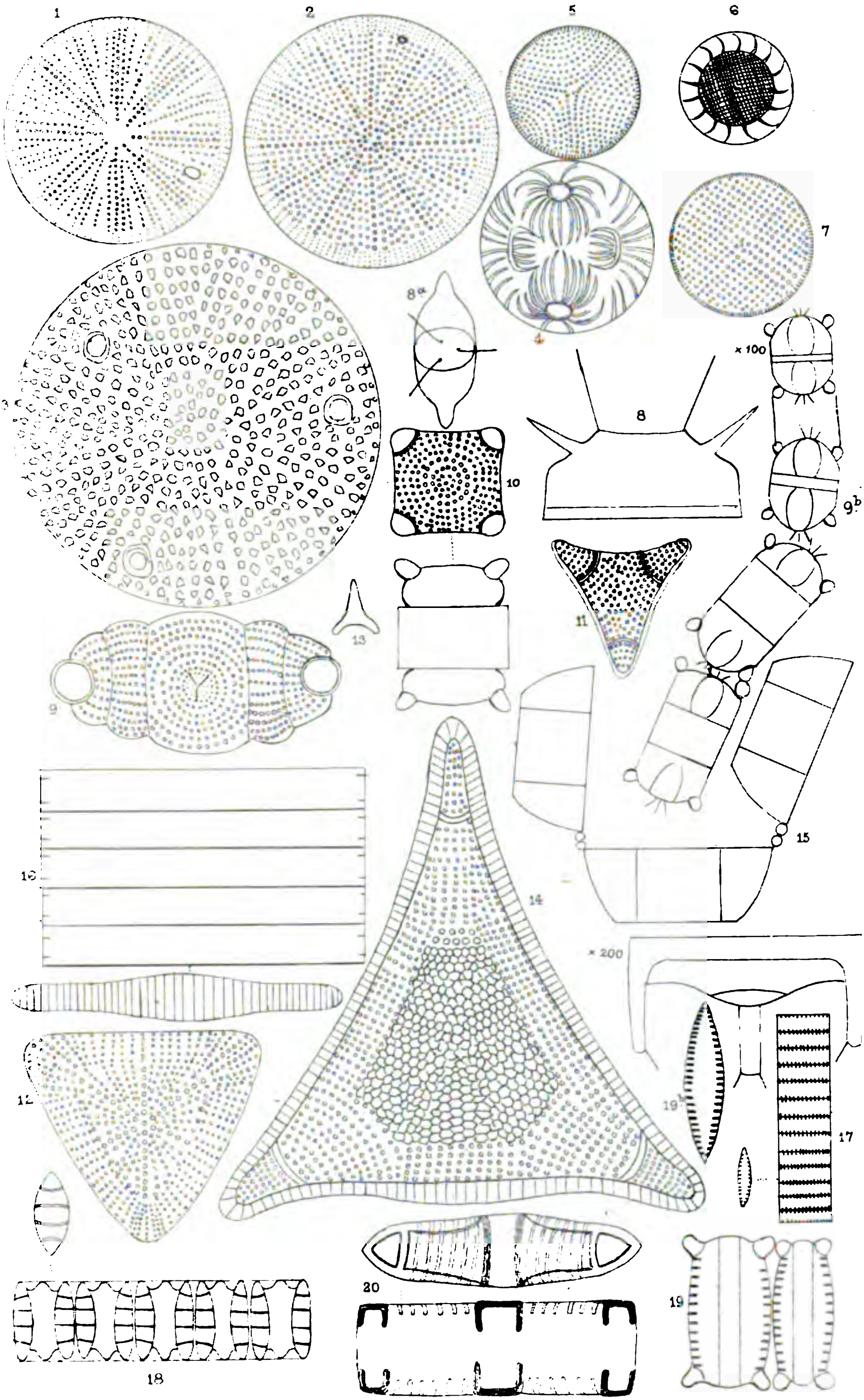
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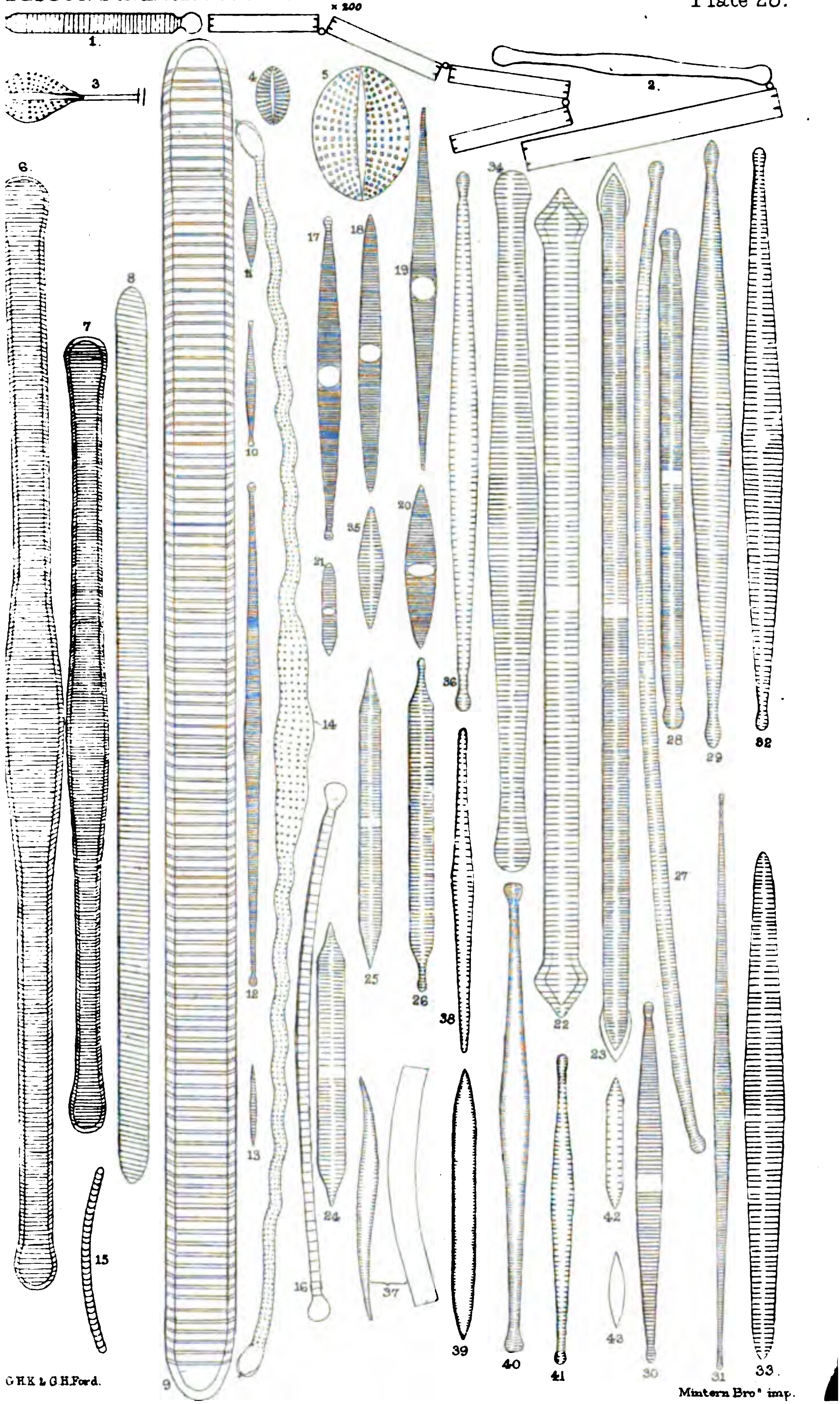
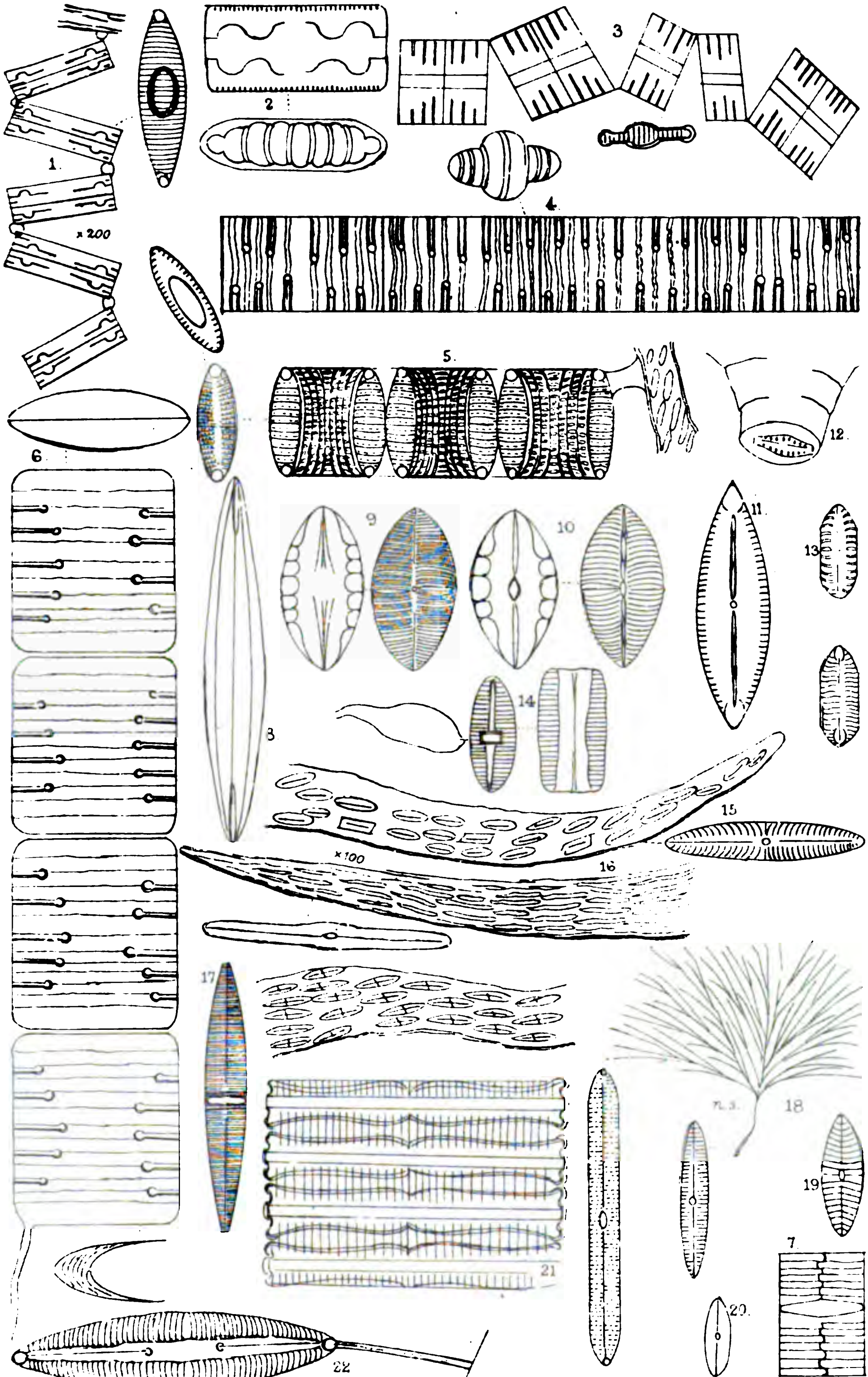


G. H. K. & G. H. Ford. Mintern Bros. imp.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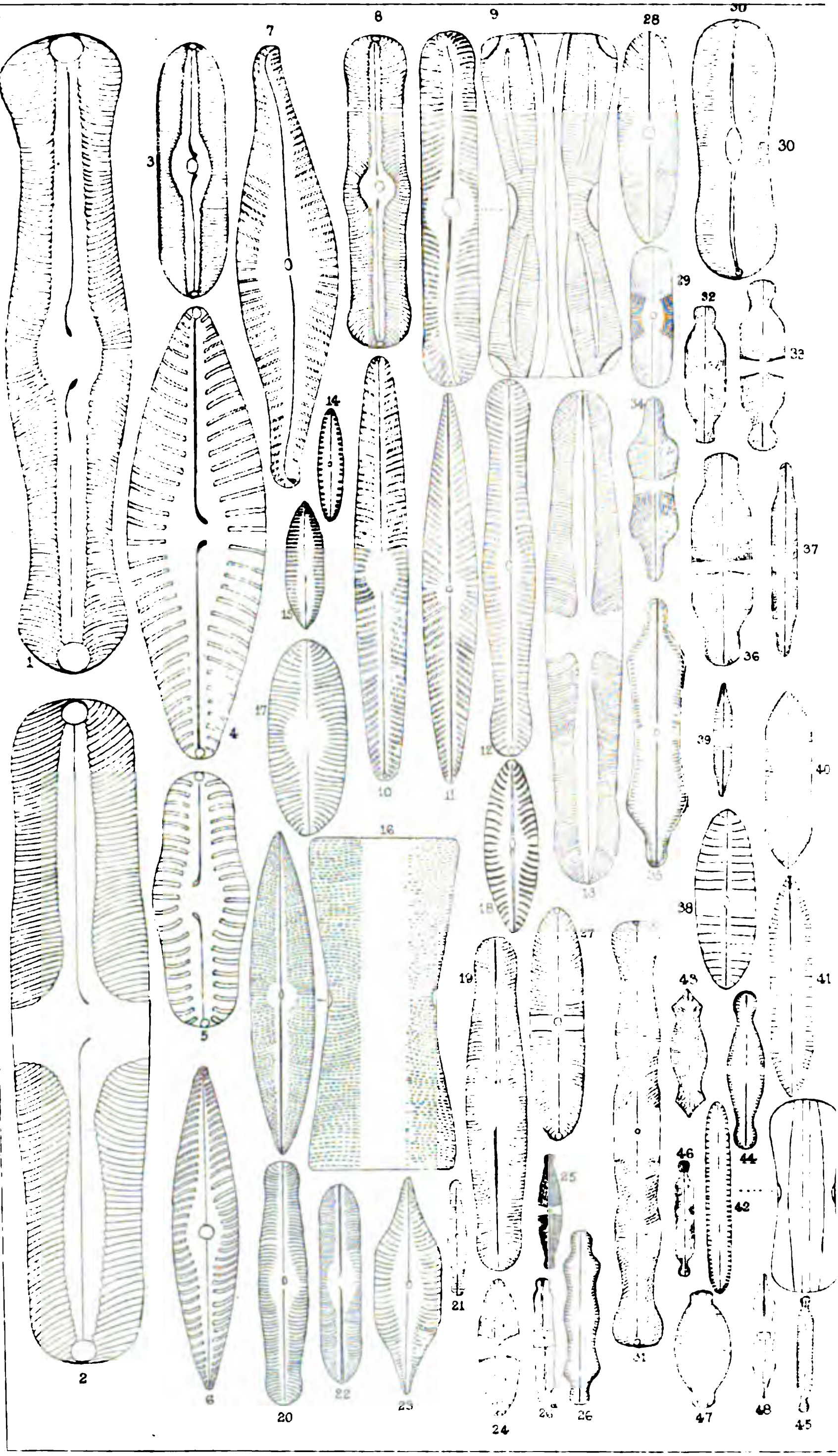
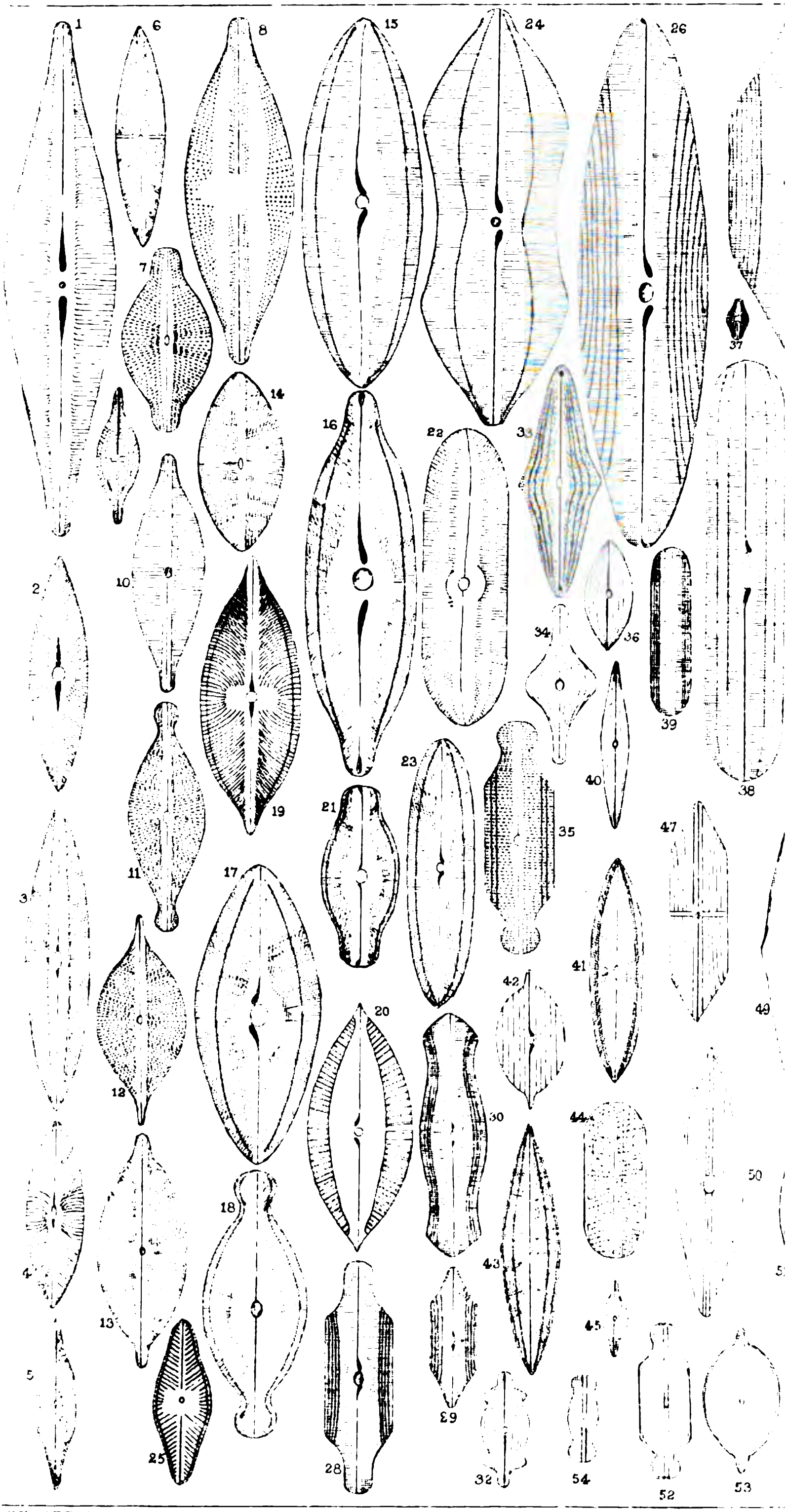


C. H. K. & G. H. Ford. Mintern Bros. imp.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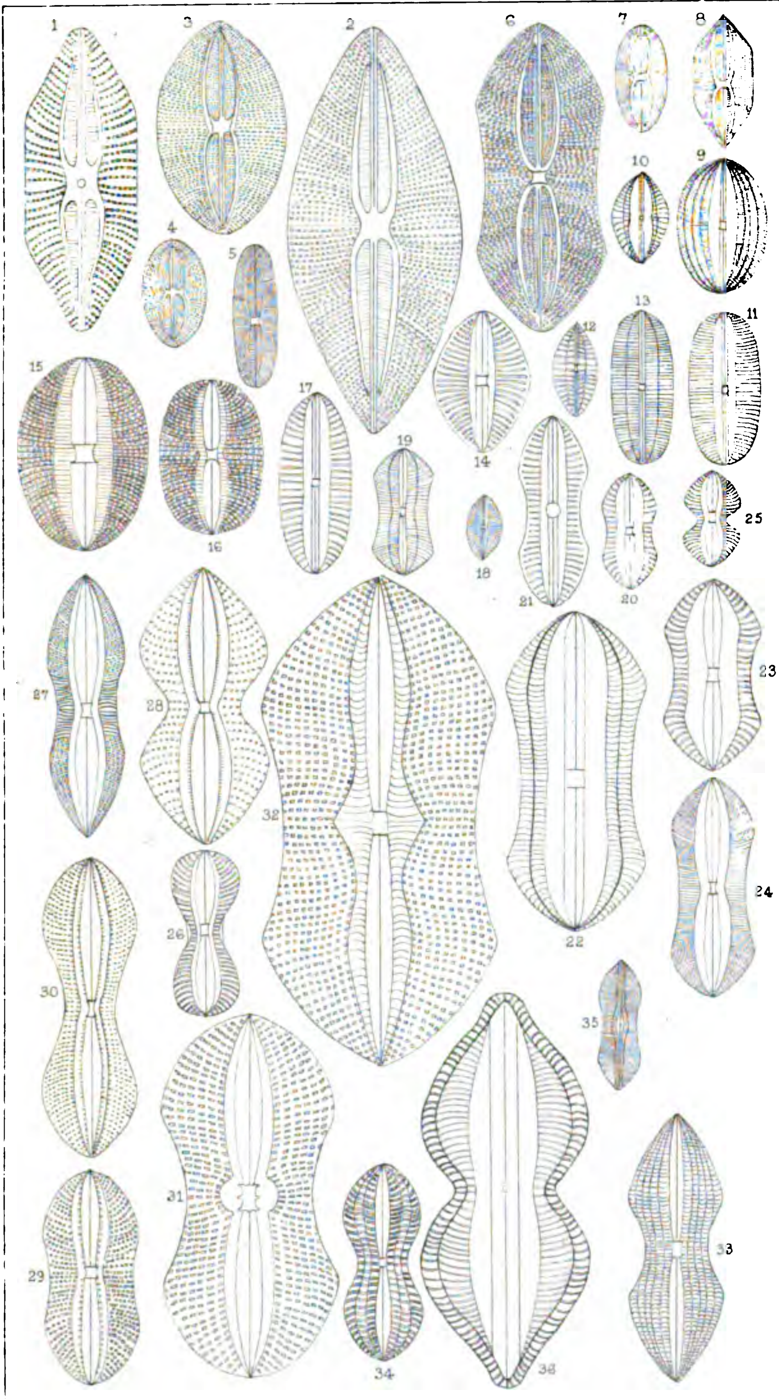
H. K. & G. H. Ford Mintern Bros imp.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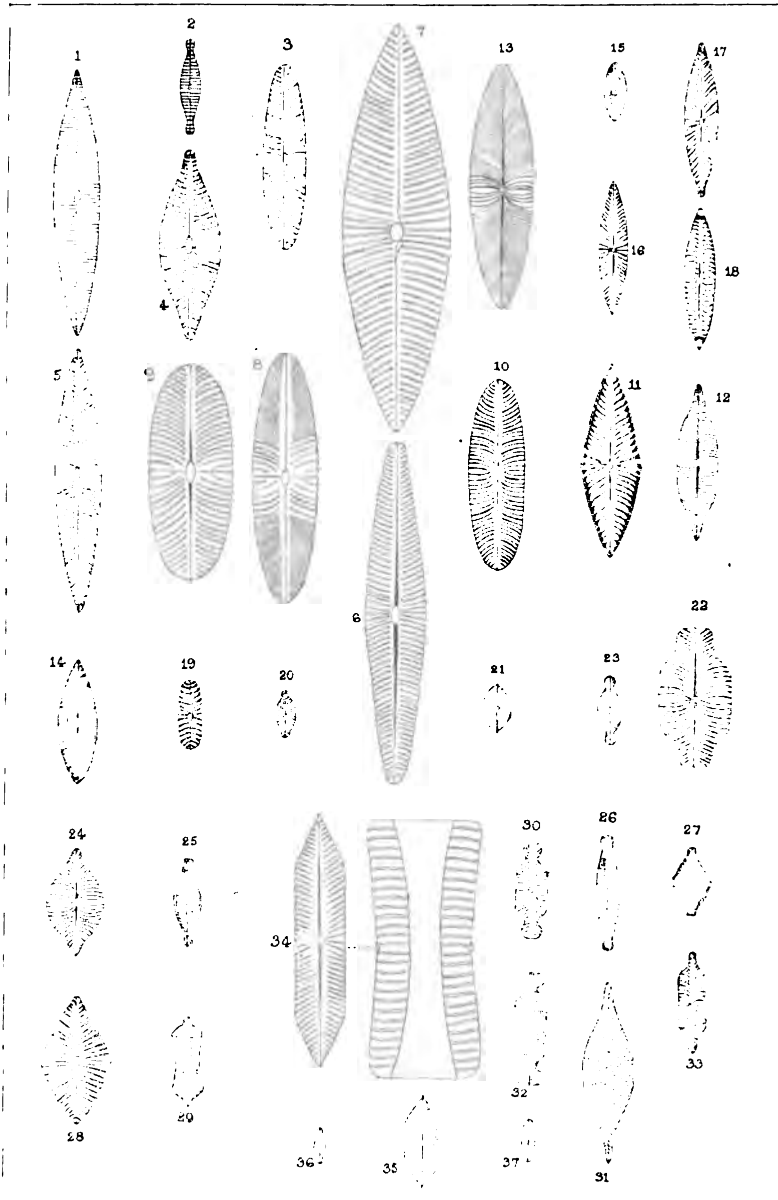

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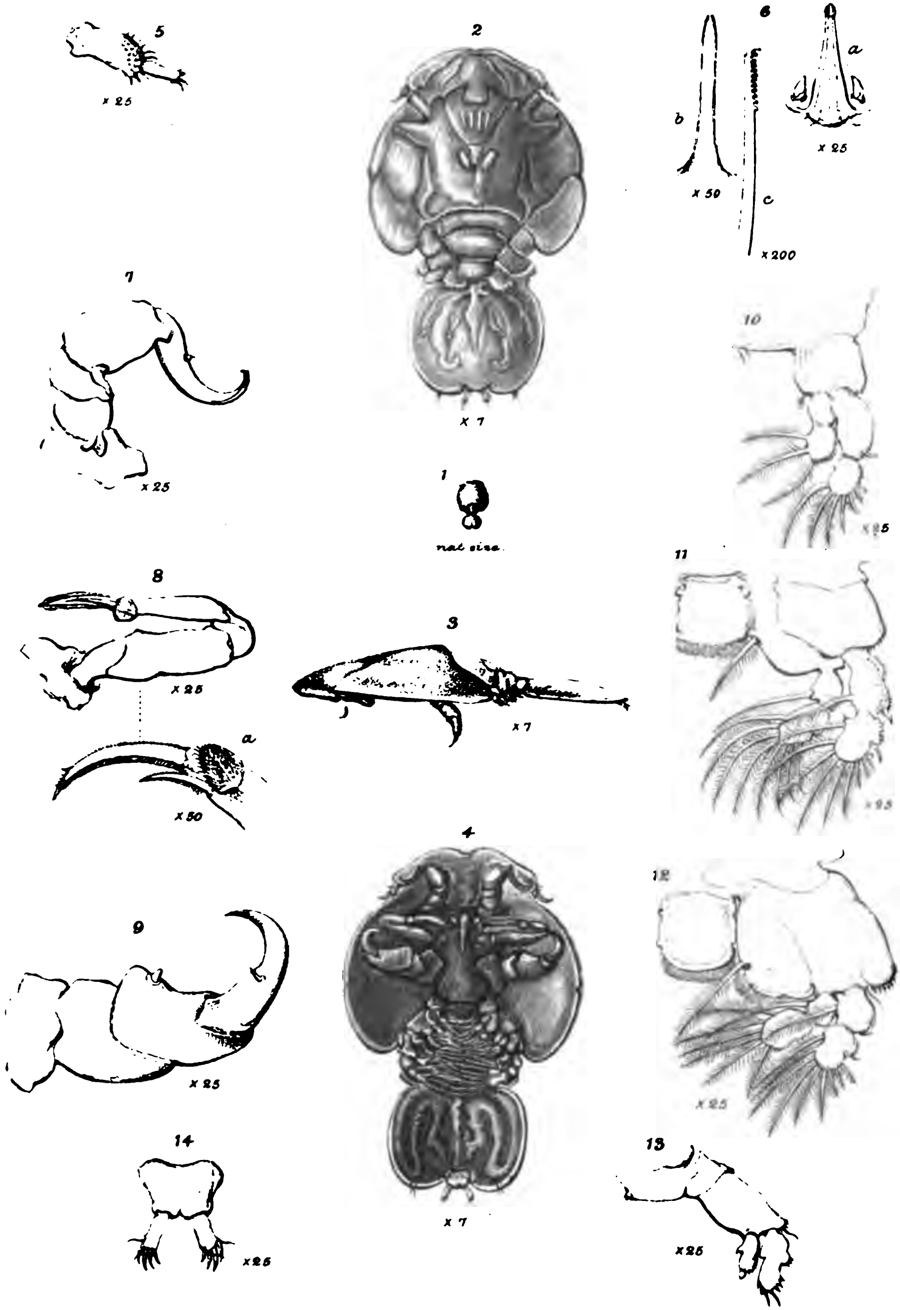

uffen West ad nat. del. W. West & Co lith.

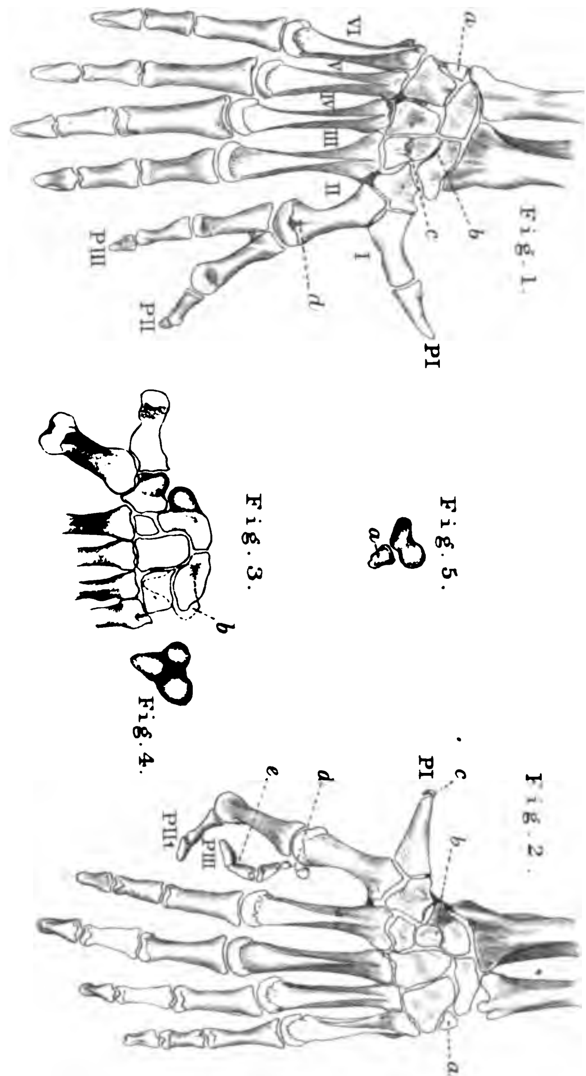
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Fig. 5.
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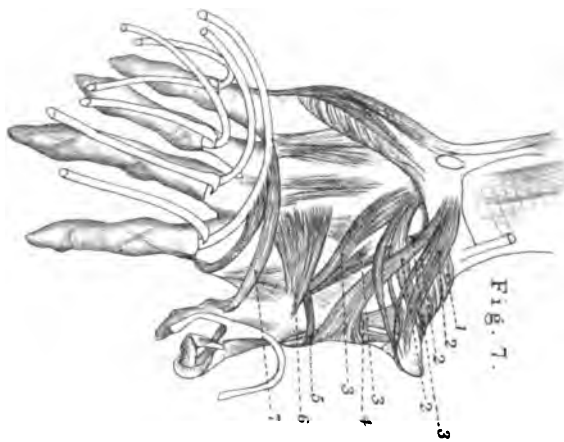

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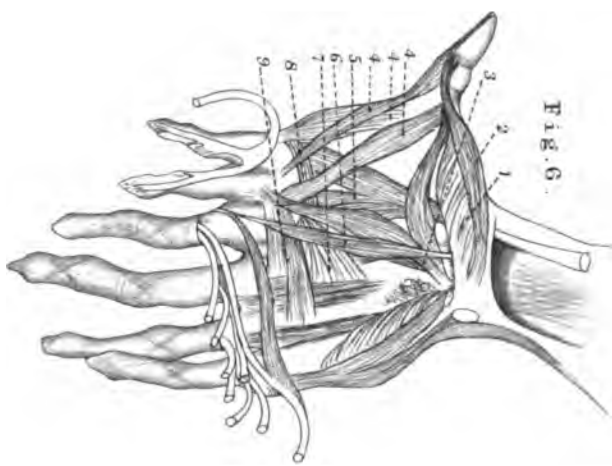

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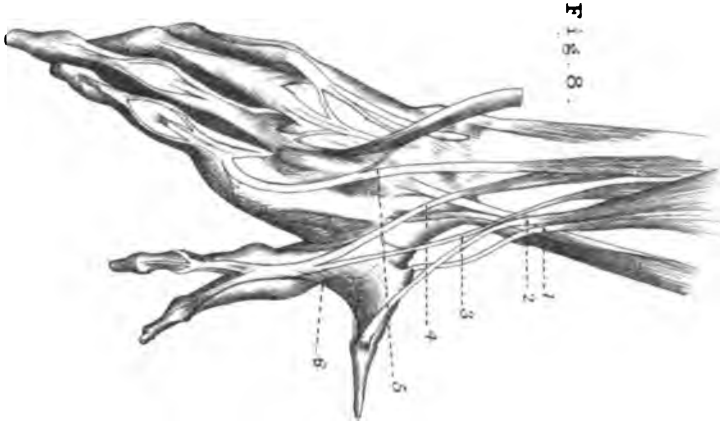

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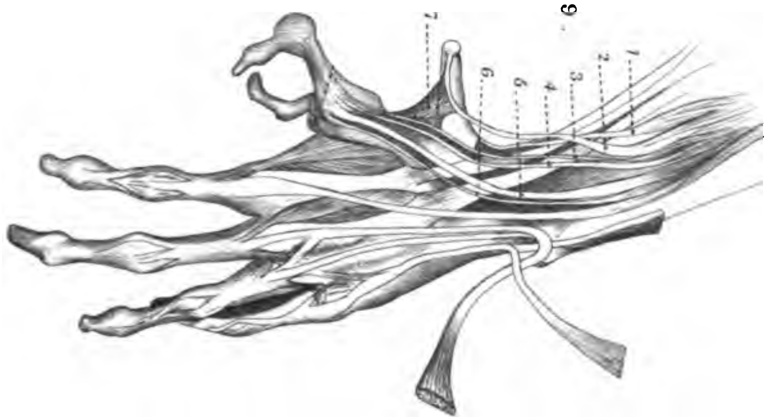


Fig. 9.

E K. Mintern Bros imp

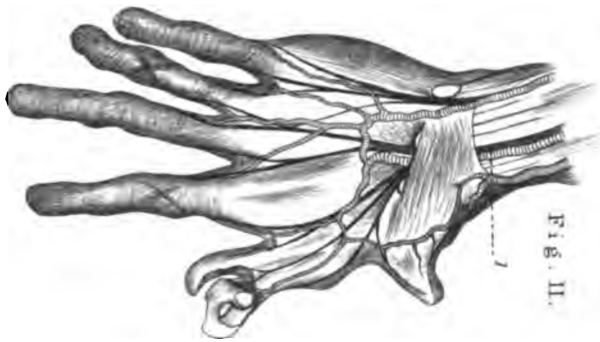
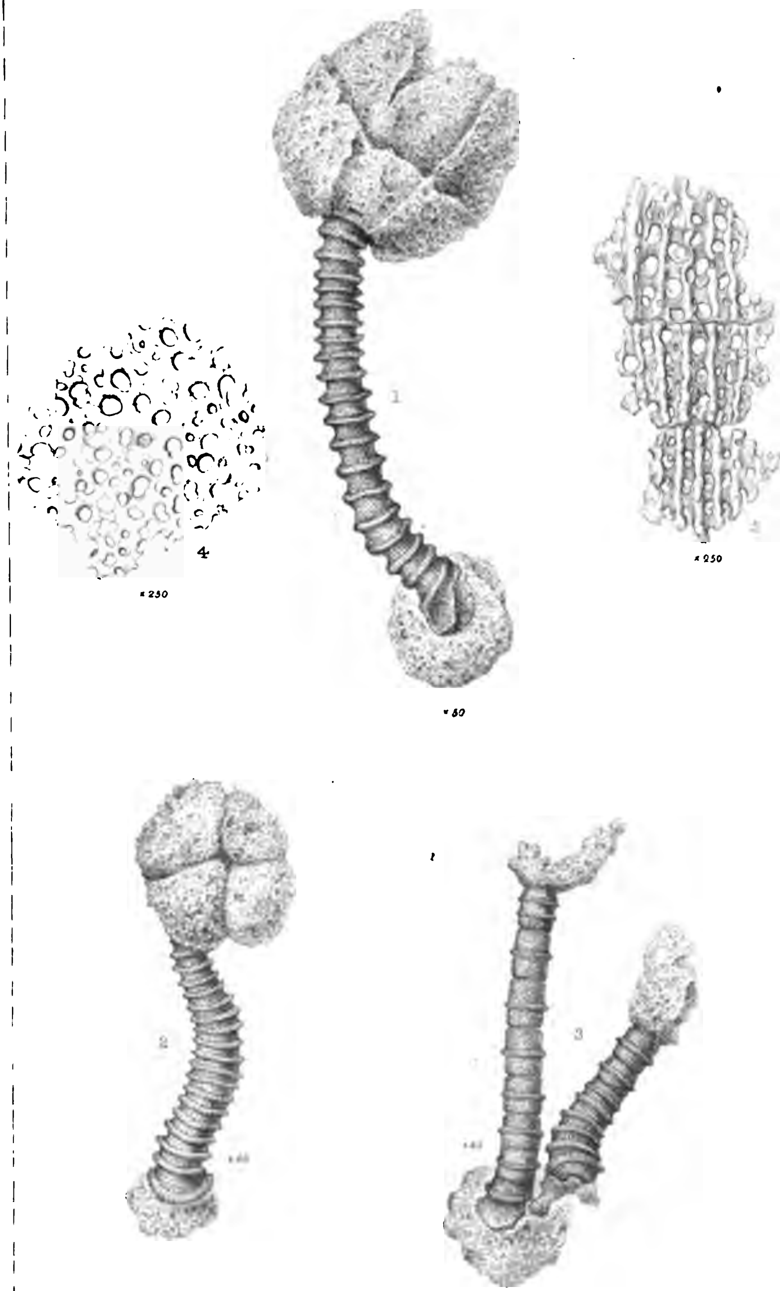


Fig. 11.

Fig. 10.



Tuffen West ad nat del et sc.

W. West & Co.

KALISPONGIA Archeri. E.P.W.

Fig. 1.

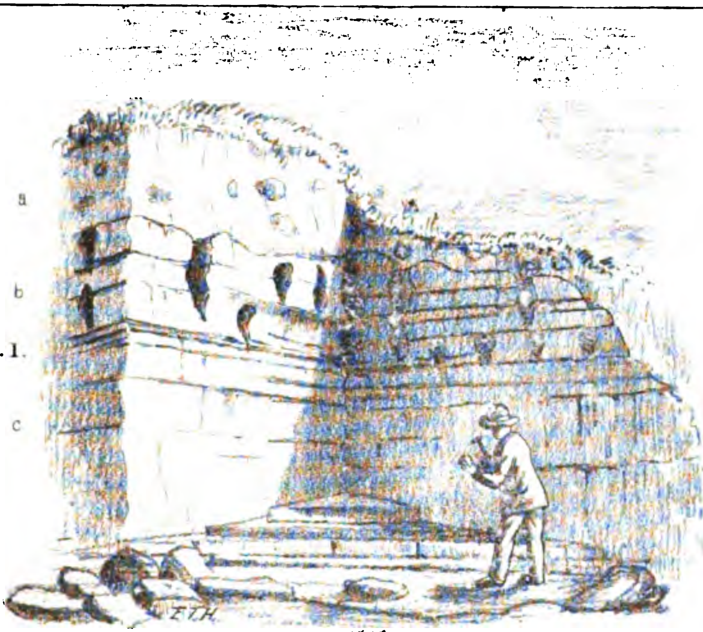


Fig. 2.

Section at Riverview Kilkenny.

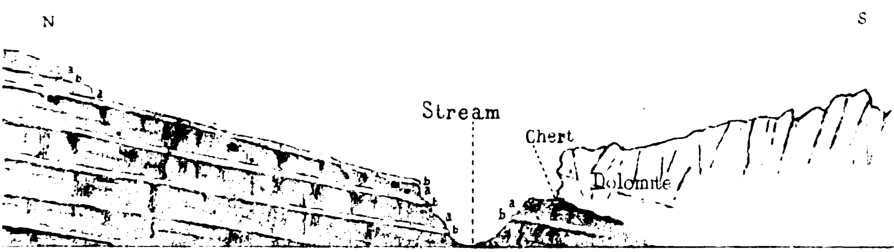
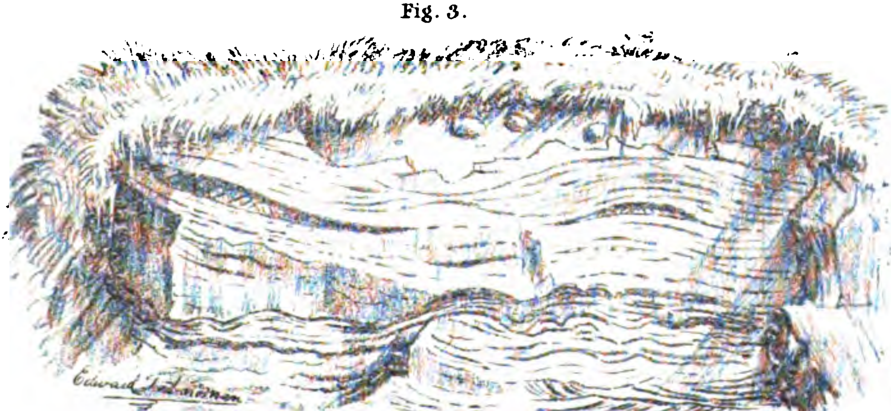
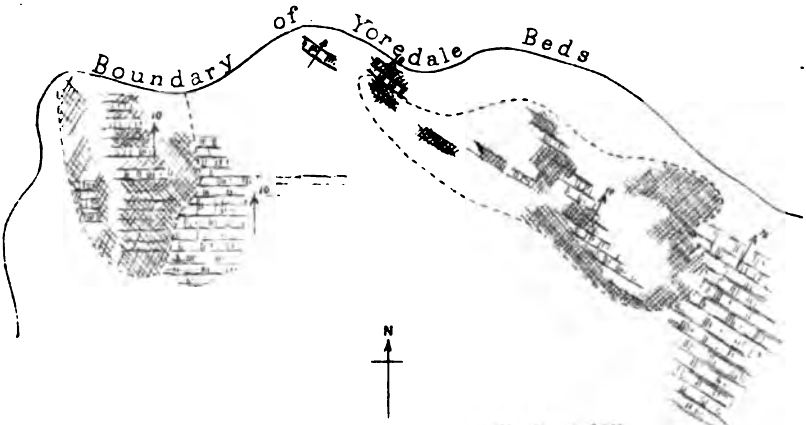


Fig. 3.



Edward. T. Hardman. delt et lith. Forster & C° Lith Dublin.

Fig. 4.



Plan of Limestones and Dolomites Ballyfoyle Kilkenny.
Scale Six inches to one mile.

Fig. 5

Section at Ballyfoyle

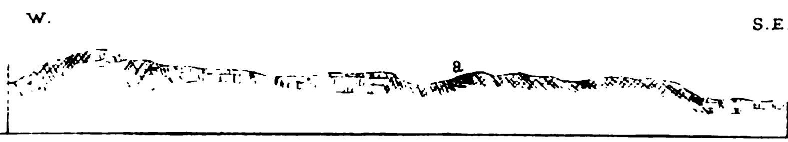
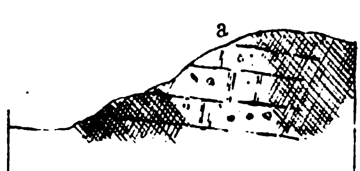


Fig. 6.

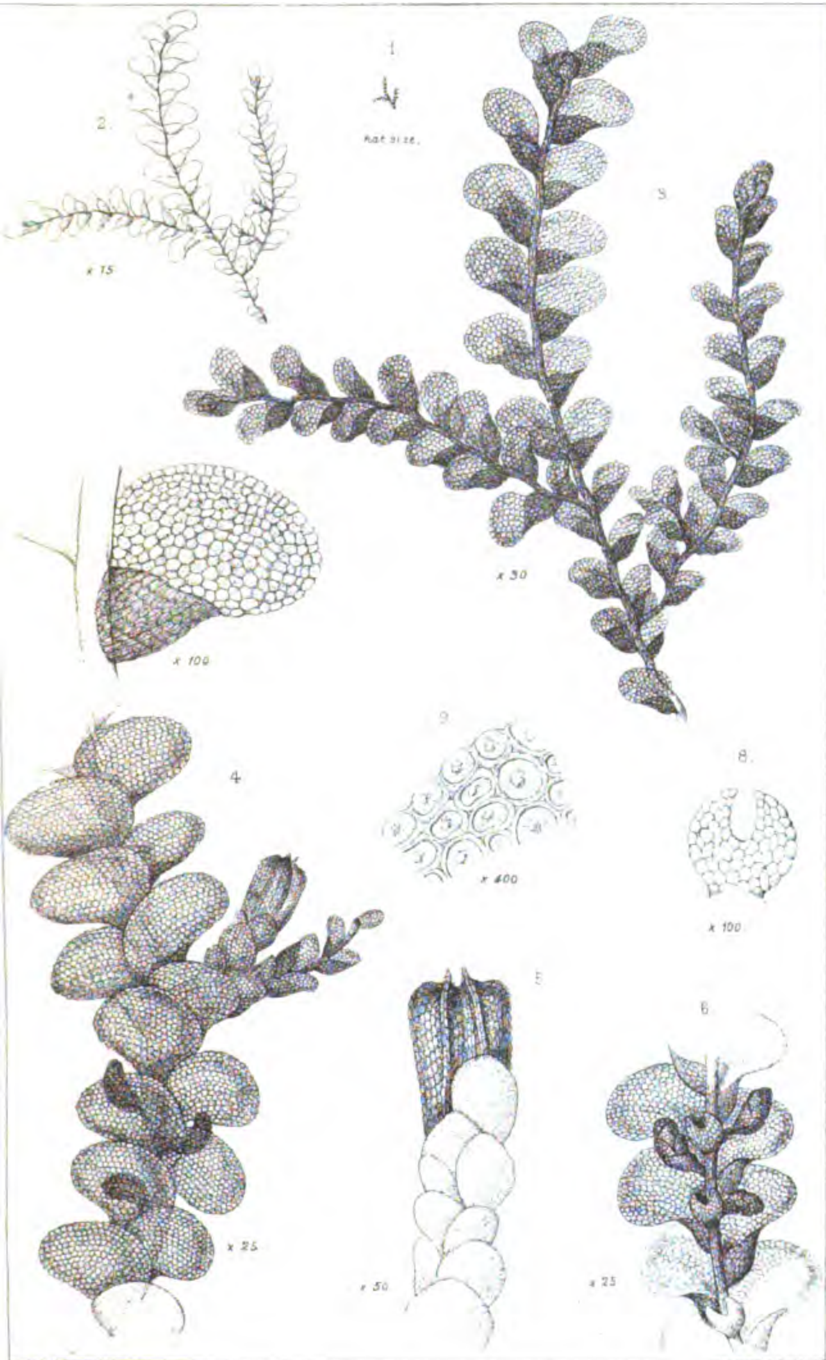
Enlarged sketch of (a) Fig 5.



Carboniferous Limestone.

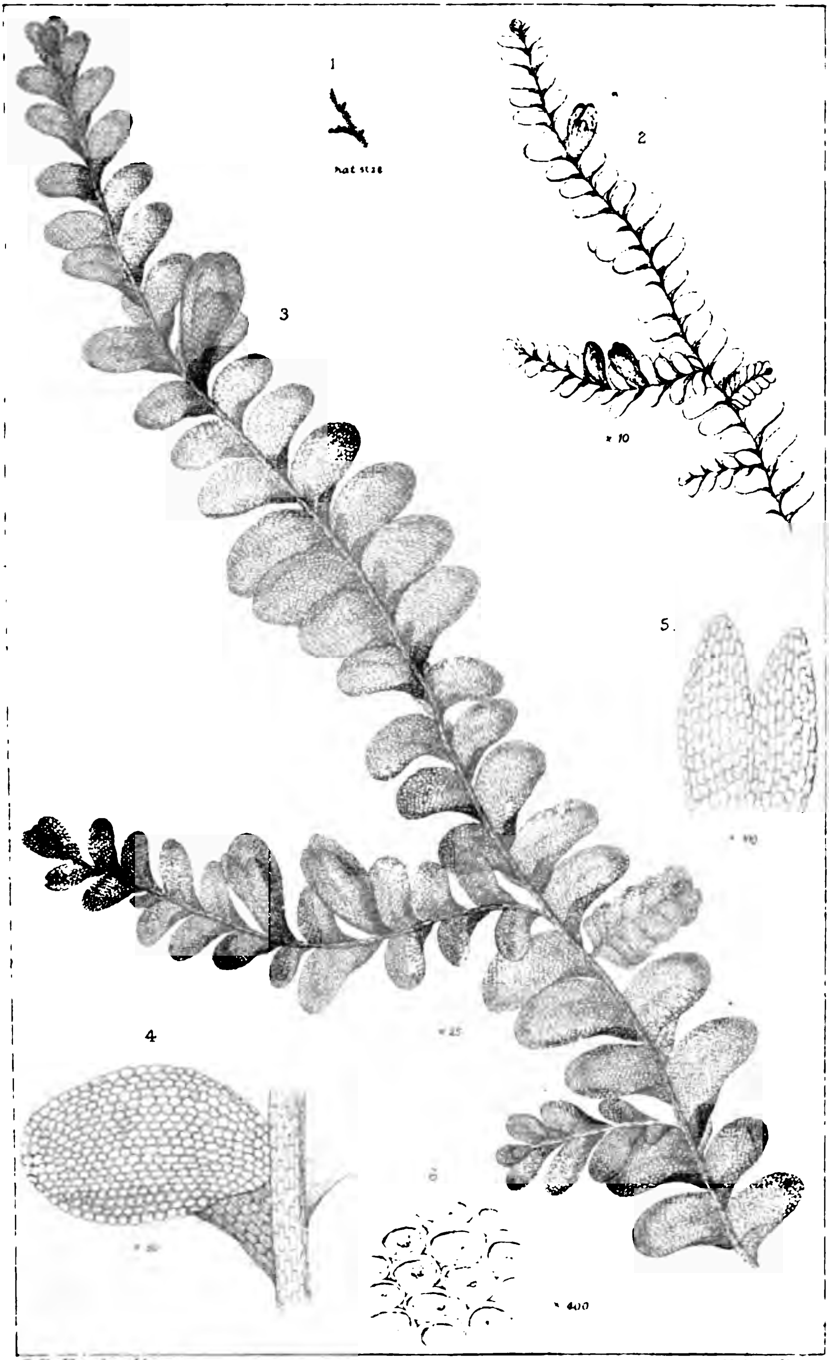
" Dolomite.

Edward T. Hardman. delt et lith. Forster & C° Lith Dublin.

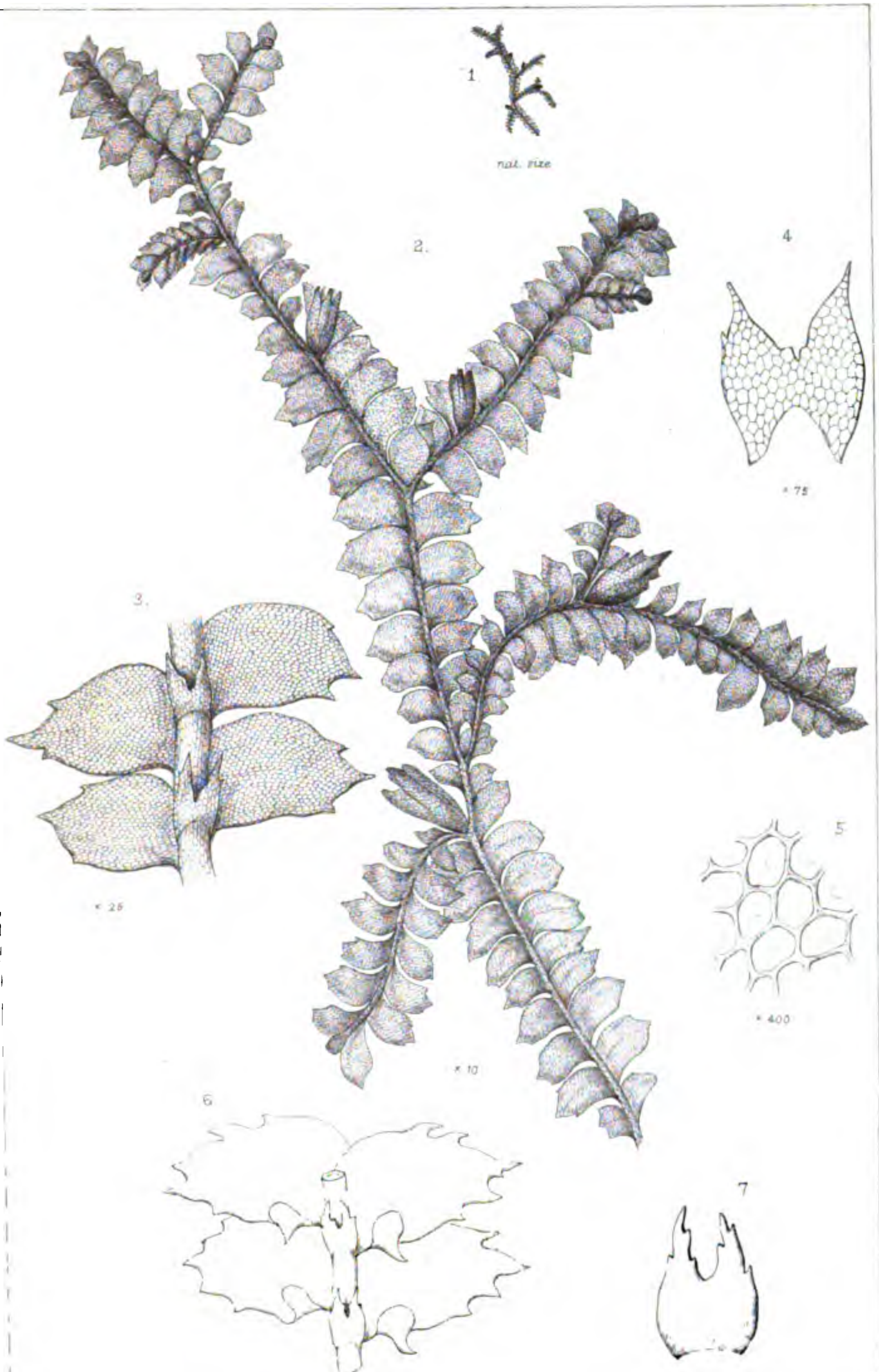


Tuffen West ad nat del. et sc. W. West & Co. imp.

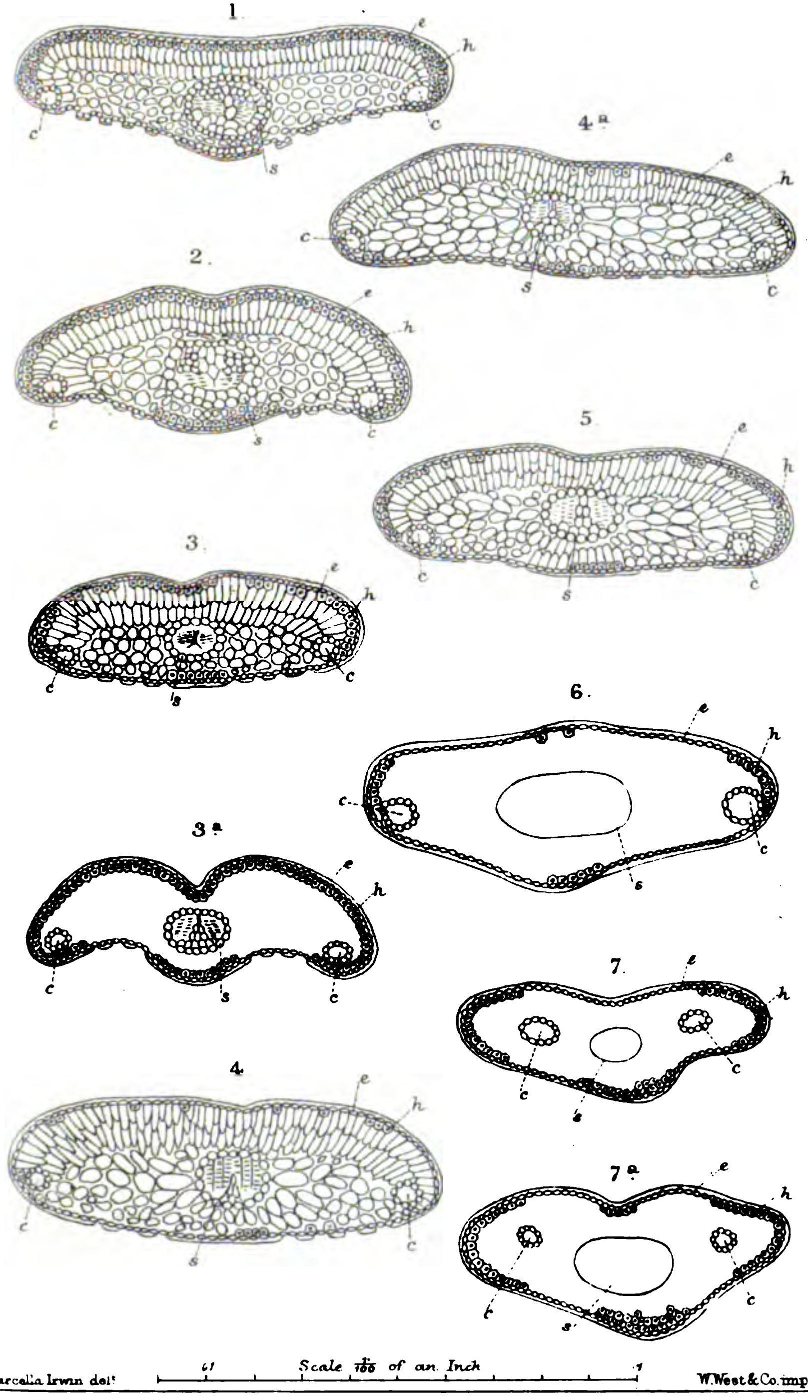
LEJEUNIA patens Lindb.



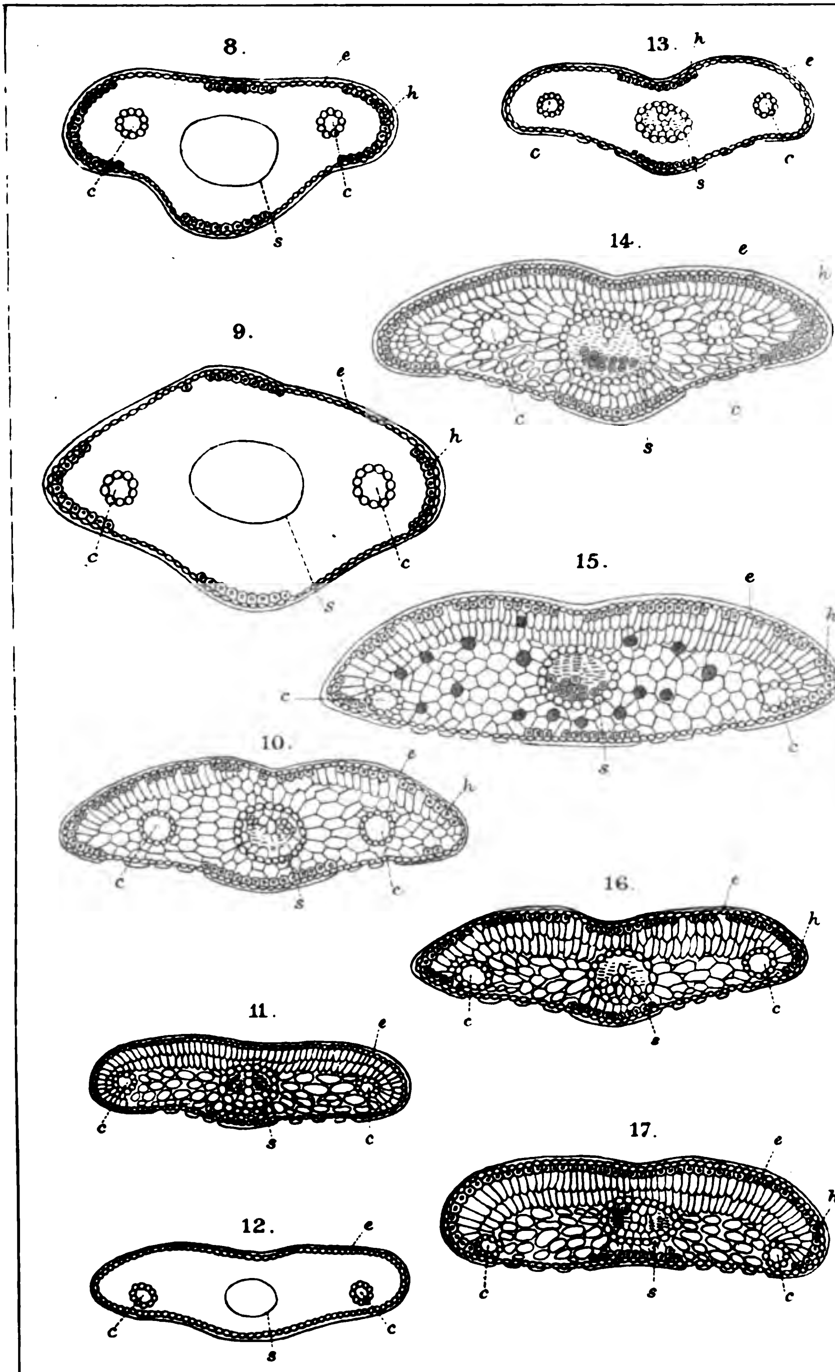
LEJEUNIA Moorei. Lindb



FRULLANIA Hutchinsiæ β integrifolia N.L.



Marcella Irwin delt W. West & Co. imp.



Marcella Irwin delt. W. West & Co imp.

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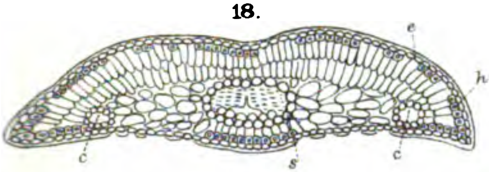

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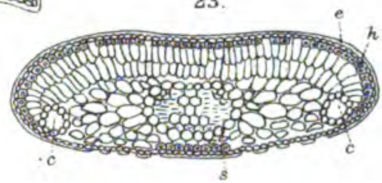

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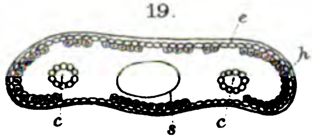

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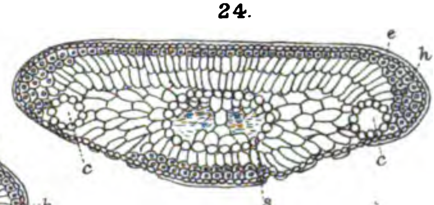

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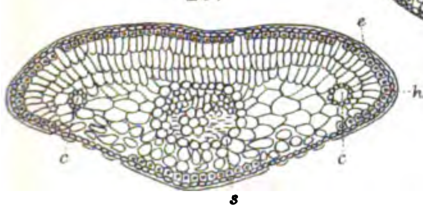

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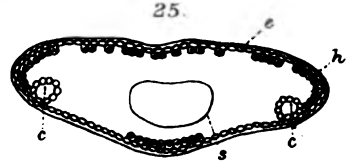

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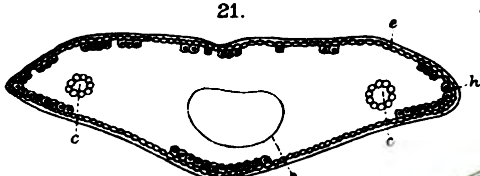

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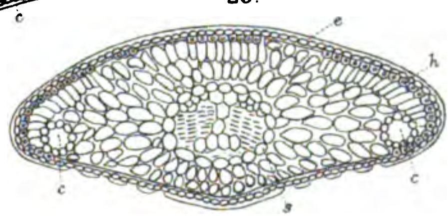

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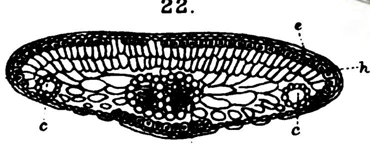

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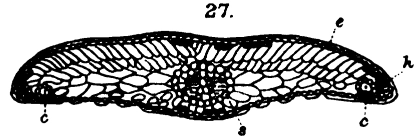
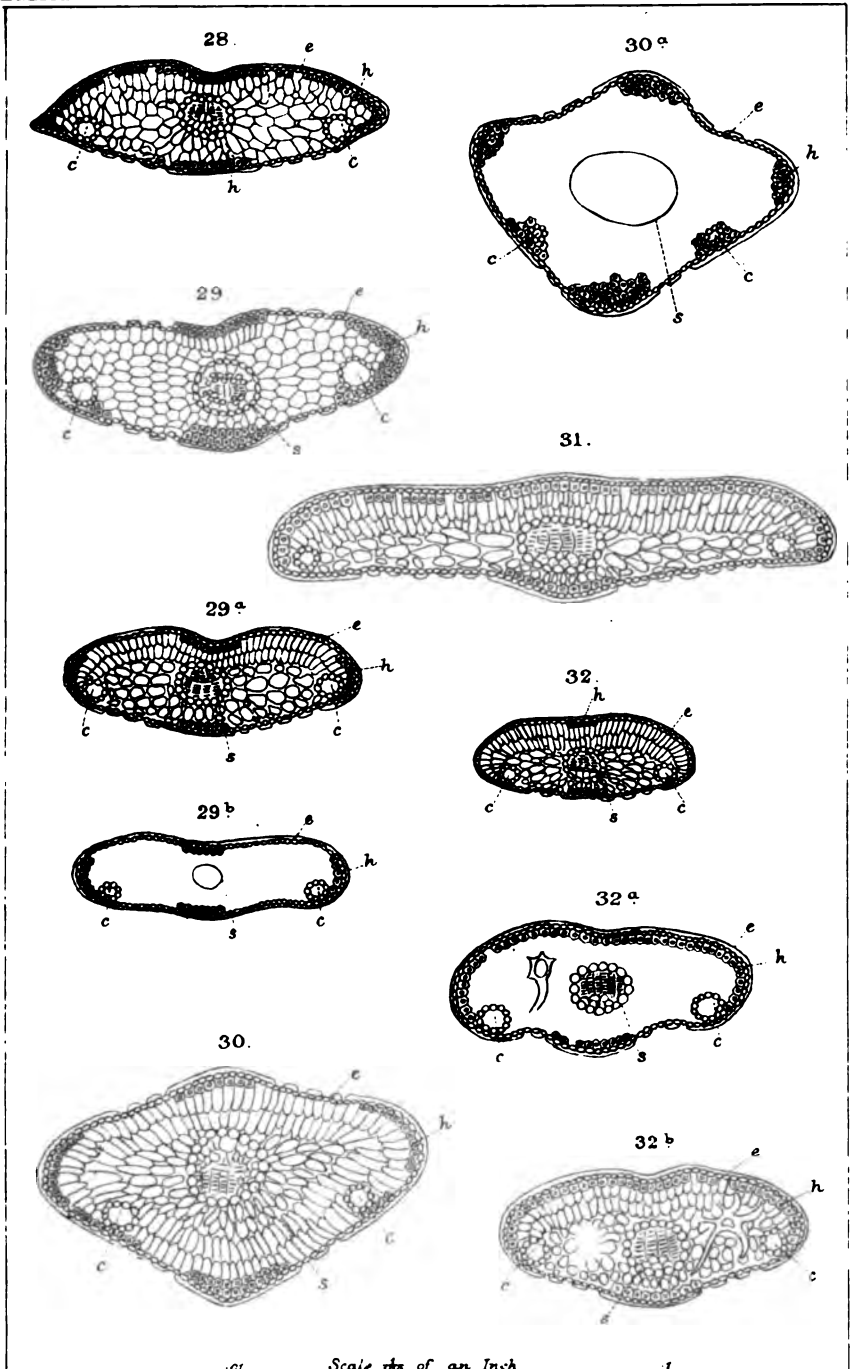


Marcella Irwin del[t]. ·01 *Scale 1/100 of an Inch* ·1 W. West & Co imp.



Marcella Irwin del.   W. West & Co. imp.

LIST

OF THE

COUNCIL AND OFFICERS

AND

MEMBERS

OF THE

ROYAL IRISH ACADEMY;

DUBLIN,

1st of September, 1875.

DUBLIN:
ACADEMY HOUSE, 19, DAWSON STREET.
1875.

THE ROYAL IRISH ACADEMY,

A.D. 1875.

Patron:

HER MAJESTY THE QUEEN.

Visitor:

HIS EXCELLENCY THE LORD LIEUTENANT OF IRELAND.

ROYAL IRISH ACADEMY.

President:

(*First elected*, 16*th of March*, 1874.)

WILLIAM STOKES, M.D., LL.D., D.C.L., F.R.S., F.K. & Q.C.P.I.

The Council:

(*Elected* 16*th of March*, 1875.)

The Council consists of the Committees of Science and of Polite Literature and Antiquities.

Committee of Science (ELEVEN MEMBERS):

	Elected.		
(1)	Mar.,	1870	REV. SAMUEL HAUGHTON, M.D., F.R.S., D.C.L., F.T.C.D.
(2)	,,	1870	EDWARD PERCEVAL WRIGHT, M.D. F.L.S., F.R.C.S.I. (*Sec.*)
(3)	,,	1872	DAVID MOORE, PH.D., F.L.S.
(4)	,,	1872	JOHN CASEY, LL.D.
(5)	,,	1873	THOMAS HAYDEN, F.K. & Q.C.P.I., EX-F.R.C.S.I.
(6)	,,	1874	REV. JOHN HEWITT JELLETT, B.D., S.F.T.C.D.
(7)	,,	1874	ALEXANDER MACALISTER, M.B.
(8)	,,	1875	SIR ROBERT KANE, M.D., LL.D., F.R.S., F.K. & Q.C.P.I.
(9)	,,	1875	ALEXANDER CARTE, M.D., F.L.S.
(10)	,,	1875	GEORGE JOHNSTONE STONEY, M.A., F.R.S.
(11)	,,	1875	WILLIAM ARCHER, F.R.S.

Committee of Polite Literature and Antiquities (TEN MEMBERS):

(12)	Mar.,	1856	JOHN THOMAS GILBERT, F.S.A., R.H.A.
(13)	,,	1859	JOHN KELLS INGRAM, LL.D., F.T.C.D.
(14)	,,	1867	SAMUEL FERGUSON, LL.D., Q.C.
(15)	,,	1867	WILLIAM JOHN O'DONNAVAN, LL.D.
(16)	,,	1869	ALEXANDER GEORGE RICHEY, LL.D., Q.C.
(17)	Dec.,	1869	JOHN RIBTON GARSTIN, M.A. & LL.B., F.S.A. (*Sec.*)
(18)	Mar.,	1871	VERY REV. WILLIAM REEVES, D.D., LL.D., M.B., Dean of Armagh.
(19)	,,	1873	REV. THADDEUS O'MAHONY, D.D.
(20)	,,	1875	REV. MAXWELL CLOSE, M.A.
(21)	,,	1875	ROBERT ATKINSON, LL.D.

This Council will continue till March 16, 1876.

Vice-Presidents:

(As nominated by the President, 16th of March, 1875: with the dates from which they have continuously been re-appointed.)

1. VERY REV. WILLIAM REEVES, D.D., LL.D., M.B., Dean of Armagh, (1874).
2. REV. SAMUEL HAUGHTON, M.D., D.C.L., F.R.S., F.T.C.D., (1871).
3. SAMUEL FERGUSON, LL.D., Q.C., (1870).
4. SIR ROBERT KANE, M.D., LL.D, F.R.S., (1875).

Officers:

(Elected annually by the Academy; with dates of first election.)

TREASURER	JOHN RIBTON GARSTIN, M.A. & LL.B., F.S.A., (1871).
SECRETARY	EDWARD PERCEVAL WRIGHT, M.A., M.D., F.L.S., (1874).
SECRETARY OF THE COUNCIL	JOHN KELLS INGRAM, LL.D., F.T.C.D., (1860).
SECRETARY OF FOREIGN CORRESPONDENCE	WILLIAM ARCHER, F.R.S., (1875).
LIBRARIAN	JOHN THOMAS GILBERT, F.S.A., R.H.A., (1861).

Clerk of the Academy, (elected annually by the Academy)	EDWARD CLIBBORN, ESQ., (1839).
Curator, Museum-Clerk, and Housekeeper, .	CAPT. ROBERT MACENIRY, (1872).
Irish Scribe, ...	MR. J. O'LONGAN, (1865).
Assistant Accountant, ...	MR. EDWARD SPENCER, B.A., (1873).
Library Clerk, ...	MR. J. J. MACSWEENEY, (1869).
Assistant in Library, ...	MR. R. J. O'MULRENIN, (1872).
Serjeant-at-Mace, ...	(*Vacant*).

Committees appointed by Council:

These Committees are composed of the Members of Council, to whose names the subjoined numbers are prefixed in the foregoing list:

Museum, . .	Committee of Polite Literature and Antiquities. *Sec.* No. 17.
Publication, .	2 (*Sec.*), 8, 9, 10; 12, 13, 17, 20.
Library, . .	2, 3, 5, 8, 11; 12 (*Sec.*), 13, 15, 17, 21.
Irish Manuscripts,	4; 12 (*Sec.*), 13, 14, 15, 17, 18, 19, 21.
Economy & House,	2, 4, 5, 6; 12, 14, 17 (*Sec.*), 19.

MEMBERS OF THE ROYAL IRISH ACADEMY.

ORDINARY MEMBERS.

The sign * is prefixed to the names of Life Members.
The sign † indicates the Members who have not yet been formally admitted.
N.B.—The names of *Members whose addresses are not known* to the Secretary of the Academy, are printed in italics. He requests that they may be communicated to him.

Date of Election.	
1866. Jan. 8	Adams, Rev. Benjamin William, D.D. *Cloghran Rectory, Drumcondra, Co. Dublin.*
1843. April 10	*Allman, George James, Esq., M.D. (Dub. and Oxon.), Pres. Lin. Soc., F.R.C.S.I., F.R.SS., Lond. & Edin. *Upper Phillimore Gardens, London, S.W.*
1871. June 12	*†Amhurst, William A. Tyssen-, Esq., D.L., F.S.A., M.R.S.L. *Didlington Hall, Brandon, Norfolk.*
1873. Jan. 13	Andrews, Arthur, Esq. *Newtown House, Blackrock, Co. Dublin.*
1839. Jan. 14	*Andrews, Thomas, Esq., M.D., LL.D. (Edin.), F.R.S., Hon. F.R.S. Ed., F.C.S., Vice-President, and Professor of Chemistry, Queen's College, Belfast. *Queen's College, Belfast.*
1842. Jan. 10	*Andrews, William, Esq., F.R.G.S.I. *Ashton, The Hill, Monkstown, Co. Dublin.*
1828. April 28	*Apjohn, James, Esq., M.D., F.R.S., F. and Hon. F., K. & Q.C.P.I., F.C.S., Professor of Mineralogy and of Applied Chemistry, Dublin Univ. *South Hill, Blackrock, Co. Dublin.*
1870. Jan. 10	*Archer, William, Esq., F.R.S., Secretary of Foreign Correspondence. *St. Brendan's, Grosvenor-road, E., Rathmines, Co. Dublin.*
1815. Mar. 16	**Ashburner*, John F., Esq., M.D., M.R.C. Phys. Lon.
1875. Jan. 11	Atkinson, Robert, Esq., LL.D., Professor of Romance Languages, Univ. Dub. 20, *Garville-avenue, Rathgar, Co. Dublin.*
1863. June 8	*†Bagot, C. Neville, Esq., J.P. *Aughrane Castle, Ballygare.*
1872. April 8	Baily, William Hellier, Esq., F.L.S., F.G.S., Demonstrator in Palæontology, R.C.Sci.I. *Apsley Lodge,* 92, *Rathgar-road, Co. Dublin;* 14 *Hume-street, Dublin.*
1866. June 11	Baker, John A., Esq., F.R.C.S.I. 4, *Clare-st., Dublin.*

Date of Election.	
1872. June 24	Baldwin, Thomas, Esq. *Model Farm, Glasnevin, Co. Dublin.*
1840. April 13	*Ball, John, Esq., M.A., F.R.S., F.L.S. 10, *South-well Gardens, South Kensington, London, S.W.*
1870. Jan. 10	Ball, Robert Stawell, Esq., LL.D., F.R.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland. *The Observatory, Dunsink, Co. Dublin.*
1842. Jan. 10	*Banks, John T., Esq., M.D., F.K. & Q.C.P.I. 10, *Merrion-square, East, Dublin.*
1851. April 14	*Barker, John, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 48, *Waterloo-road, Dublin.*
1868. Jan. 13	*Barker, W. Oliver, Esq., M.D., M.R.C.S.E. 6, *Gardiner's-row, Dublin.*
1874. May 11	Barrett, William F., Esq., F.R.C.S.E., Professor of Physics, Royal College of Science. 9, *Mount-pelier-parade, Monkstown, Co. Dublin.*
1866. May 14	Barrington, Sir John, D.L. *St. Anne's, Killiney, Co. Dublin.*
1865. Jan. 9	*Beauchamp, Robert Henry, Esq. 116, *Grafton-street, Dublin.*
1868. April 27	*Belmore, Right Hon. Somerset-Richard, Earl of, M.A., D.L., K.C.M.G. *Castle Coole, Enniskillen.*
1866. June 11	Bennett, Edward Hallaran, Esq., M.D., M.Ch., F.R.C.S.I., F.R.G.S.I., Professor of Surgery in the University of Dublin. 26, *Fitzwilliam-street, Lower, Dublin.*
1825. Nov. 30	*Benson, Charles, Esq., M.A., M.B., F.R.C.S.I. 42, *Fitzwilliam-square, (West), Dublin.*
1851. June 8	†Beresford, Right Hon. and Most Rev. Marcus G., D.D., D.C.L., Lord Archbishop of Armagh, Primate of all Ireland. *The Palace, Armagh.*
1846. April 13	*Bevan, Philip, Esq., M.D. (Dub.), Prof. of Anatomy and Fellow R.C.S.I. 52, *Fitzwilliam-square, (West), Dublin.*
1849. Jan. 8	*†Bewglass, Rev. James, LL.D. *Wakefield, Yorkshire.*
1843. Dec. 11	*Bewley, Edward, Esq. *Edington, Clara, King's County.*
1843. Jan. 9	*Blacker, Stewart, Esq., M.A., J.P. *Carrick Blacker, Portadown.*
1871. Jan. 9	†Bourke, Very Rev. (Canon) Ulick J., President of St. Jarlath's College, Tuam. *St. Jarlath's, Tuam.*
1873. April 14	†Boyd, Michael A., Esq., F.R.C.S.I., L.K. & Q.C.P.I. 90, *George's-street, Upper, Kingstown, Co. Dublin.*
1854. April 10	*Brady, Cheyne, Esq. *(Abroad.)*
1849. April 9	*Brady, Daniel Fredk., Esq., F.R.C.S.I., §M.R.C.S.E. *La Choza, Rathgar-road, Co. Dublin.*
1865. April 10	†Brash, Richard Rolt, Esq., *Sunday's Well, Cork.*

Date of Election.	
1858. April 12	†Brooke, Thomas, Esq., D.L. *The Castle, Lough Eske, Strabane, Co. Donegal.*
1851. Jan. 13	*†Browne, Robert Clayton, Esq., M.A., D.L. *Browne's Hill, Carlow.*
1874. Feb. 9	†Burden, Henry, Esq., M.A., M.D., M.R.C.S.E. 9, *College-square, North, Belfast.*
1854. April 10	Burke, Sir John Bernard (Ulster), LL.D., C.B. *Tullamaine Villa, Leeson-street, Upper, Dublin.*
1855. Jan. 8	*Butcher, Richard G., Esq., M.D., F.R.C.S.I., M.R.C.S.E. 19, *Fitzwilliam-street, Lower, Dublin.*
1842. Jan. 10	*Butcher, Right Hon. and Most Rev. Samuel, D.D., Lord Bishop of Meath. *Ardbraccan House, Navan.*
1866. April 9	Byrne, John A., Esq., B.A., M.B. (Dub.) 37, *Westland-row, Dublin.*
1862. April 14	Campbell, John, Esq., M.D., Professor of Chemistry, C.U.I. 36, *Leinster-road, Rathmines, Co. Dublin.*
1836. Feb. 22	*Cane, Edward, Esq., J.P. *St. Wolstan's, Celbridge, Co. Kildare.*
1873. May 12	†Carlingford, Right Hon. Chichester, Baron, D.L., Lord Lieutenant of Essex. *Red House, Ardee;* 7, *Carlton Gardens, London, S.W.*
1838. Feb. 12	*Carson, Rev. Joseph, D.D., S.F.T.C.D., F.R.G.S.I. 18, *Fitzwilliam-place, Dublin.*
1855. Feb. 12	Carte, Alexander, Esq., M.D., F.R.C.S.I., F.R.G.S.I., Director of the Royal Dublin Society Museum of Natural History. 14, *Read's-road, Dublin.*
1866. May 14	Casey, John, Esq., LL.D., Professor of Higher Mathematics and Mathematical Physics, C.U.I. *Rose Cottage, Tivoli North, Kingstown, Co. Dublin.*
1873. Jan. 13	†Castletown of Upper Ossory, Right Hon. John-Wilson, Baron, Lieutenant of the Queen's County. *Lisduff, Errill, Templemore.*
1862. Jan. 13	*†Cather, Rev. Robert G., LL.D. *Nutty Hagg, Wandsworth Common, London, S.W.*
1843. Jan. 8	*Cather, Thomas, Esq., J.P. *Newtownlimavady.*
1842. June 13	*Chapman, Sir Benjamin J., Bart., D.L. *Killua Castle, Clonmellon.*
1864. Jan. 11	Charlemont, Right Hon. James-Molyneux, Earl of, K.P., Lieutenant of the County Tyrone. *Marino, Clontarf.*
1842. Jan. 10	*Churchill, Fleetwood, Esq., M.D., F.K. & Q.C.P.I. *Ardtrea Rectory, Stewartstown, Co. Tyrone.*
1857. April 13	*†Cleland, James, Esq., J.P. *Tobar Mhuire, Crossgar, Co. Down.*
1842. Jan. 10	**Clendinning*, Alex., Esq.
1841. Jan. 11	*†Clermont, Right Hon. Thomas, Baron, D.L. *Ravensdale Park, Newry.*

Date of Election.	
1867. May 13	*Close, Rev. Maxwell H., M.A., F.R.G.S.I. *Newtown Park, Blackrock, Co. Dublin.*
1835. Nov. 30	**Cole*, Owen Blayney, Esq., D.L.
1874. June 8	Collins, Edward Wolfenden, Esq., M.D. 33, *Baggot-street, Lower, Dublin.*
1860. Jan. 9	*Conwell, Eugene Alfred, Esq., LL.D. *Cork.*
1845. June 9	*Cooke, Adolphus, Esq. *Cooksborough, Mullingar,*
1866. April 9	†Cooper, Lieut. Col. Edward H., D.L. *Markree Castle, Collooney.*
1871. June 12	†Cooper, Major Richard, (late Scots Fusilier Guards). *Brixworth, Northampton.*
1856. April 14	Copland, Charles, Esq. *Royal Bank, Foster-place, Dublin;* 7, *Longford-terrace, Monkstown, Co. Dublin.*
1825. Nov. 30	*Corballis, John R., Esq., LL.D., Q.C. *Rosemount, Roebuck, Clonskeagh, Co. Dublin.*
1847. Jan. 11	*Corrigan, Sir Dominic J., Bart., M.D., F.K.&Q.C.P.I., Corr. For. Mem. Academie de Medecine, Paris. 4, *Merrion-square, West, Dublin.*
1864. May 9	†Cotton, Charles Philip, Esq., B.A., C.E., F.R.G.S.I. 11, *Pembroke-street, Lower, Dublin.*
1846. Jan. 12	Cotton, Rev. Henry, LL.D., D.C.L. (late Archdeacon of Cashel.) *Lismore.*
1857. Aug. 24	*Crofton, Denis, Esq., B.A. 8, *Mountjoy-square, (North), Dublin.*
1867. June 24	*†Crofton, Henry Morgan E., Esq., F.R.A.S., J.P. *Inchinappa, Ashford, Co. Wicklow.*
1866. June 11	†Cruise, Francis R., Esq., M.D., F.K. & Q.C.P.I., M.R.C.S.E. 3, *Merrion-square, West, Dublin.*
1870. Apr. 11	Cruise, Richard Joseph, Esq., F.R.G.S.I., Geological Survey of Ireland. *Boyle, Co. Roscommon;* 14, *Hume-street, Dublin.*
1874. June 8	Cryan, Robert, Esq., M.D. 54, *Rutland-square, (West), Dublin.*
1853. April 11	*Davies, Francis Robert, Esq., K.J.J. *Hawthorn, Blackrock, Co. Dublin.*
1855. May 14	Davy, Edmund W., Esq., M.A., M.D., Prof. of Med. Jurisprudence, R.C.S.I. *Elm Grove, Terenure, Co. Dublin; Royal College of Science,* 51, *St. Stephen's-green, (East), Dublin.*
1846. April 13	*D'Arcy, Matthew P., Esq., M.A., D.L. 6, *Merrion-square, East, Dublin.*
1870. Jan. 10	Day, Robert, Esq., F.S.A. *Rockview, Montenotte, Cork.*
1846. Jan. 12	*Deasy, Right Hon. Rickard, LL.D., Third Baron of the Exchequer. *Carysfort House, Blackrock, Co. Dublin.*

Date of Election.	
1851. June 9	*†De la Ponce, Mons. Amadie. *Paris.*
1849. Sept. 9	De Vesci, Right Hon. Thomas, Viscount, D.L., F.R.G.S.I. *Abbeyleix House, Abbeyleix, Queen's Co.*
1860. Jan. 9	*Dickson, Rev. Benjamin, D.D., F.T.C.D. 3, *Kildare-place, Dublin.*
1847. Jan. 11	*†Dobbin, Leonard, Esq. 27, *Gardiner's-place, Dublin.*
1851. Jan. 13	*Dobbin, Rev. Orlando T., LL.D. *Chez-moi, Cullenswood, Co. Dublin.*
1856. Feb. 11	Downing, Samuel, Esq., C.E., LL.D., F.R.G.S.I., Professor of Civil Engineering, Dublin Univ. 4, *The Hill, Monkstown, Co. Dublin.*
1873. Jan. 13	Drew, Thomas, Esq., R.H.A., F.R.I.A.I. 6, *St. Stephen's-green, (North), Dublin.*
1843. Jan. 9	*Drury, William Vallancey, Esq., M.D. 7, *Harley-street, Cavendish-square, London, W.*
1861. Feb. 11	Duncan, James Foulis, Esq., M.D., Fellow and President, K. & Q.C.P.I. 8, *Merrion-street, Upper, Dublin.*
1873. Jan. 13	Durham, James Samuel William, Esq., F.R.G.S.I. *Babbacombe, Torquay, South Devon.*
1843. Dec. 11	*†Eiffe, James S., Esq., F.R.Ast.S. *The Chestnuts, near Amersham, Buckinghamshire.*
1867. Feb. 11	Ellis, George, Esq., M.B., F.R.C.S.I. 91, *Leeson-street, Lower, Dublin.*
1841. April 12	*Emly, Right Hon. William, Baron, Lieutenant of the County Limerick. *Tervoe, Limerick; Athenæum Club, London, S.W.*
1846. Jan. 12	*Enniskillen, Right. Hon. William-Willoughby, Earl of, LL.D., D.C.L., D.L., F.R.S., F.R.G.S.I., Trustee of the Hunterian Museum, R.C.S., London. *Florence Court, Co. Fermanagh;* 65, *Eaton-place, London, S.W.*
1870. Jan. 10	†Esmonde, Sir John, Bart., M.P., D.L. *Ballynastragh, Gorey, Co. Wexford.*
1867. April 8	*Farrell, Thomas A., Esq., M.A. 3, *Merrion-square, East, Dublin.*
1854. Feb. 13	*†Ferguson, Rev. Robert, LL.D., F.S.A., F.R.S. 15, *Carlton Hill, East, St. John's-Wood, London.*
1834. Mar. 15	*Ferguson, Samuel, Esq., LL.D., Q.C., a Vice-President of the Academy. 20, *George's-street, Great, North, Dublin.*
1842. Jan. 10	*Ferrier, Alexander, Esq. *Knockmaroon Lodge, Chapelizod, Co. Dublin.*

Date of Election	
1857. Aug. 24	Fitzgerald, Right Rev. William, D.D., Lord Bishop of Killaloe, &c. *Clarisford House, Killaloe.*
1870. May 23	†FitzGibbon, Abraham, Esq., M.I.C.E. Lond. *The Rookery, Great Stanmore, Middlesex.*
1841. April 12	*Fitzgibbon, Gerald, Esq., M.A., Master in Chancery. 10, *Merrion-square, North, Dublin.*
1875. Jan. 11	Fitzpatrick, William John, Esq., J.P., LL.D. 75, *Pembroke-road, Dublin.*
1851. June 9	Fleming, Christopher, Esq., M.D., F.R.C.S.I. 6, *Merrion-square, North, Dublin.*
1860. Jan. 9	†Foley, William, Esq., M.D., M.R.C.S.E. *Kilrush.*
1874. May 11	Foot, Arthur Wynne, Esq., M.D., F.K.Q.C.P.I., F.R.G.S.I. 21, *Pembroke-street, Lower, Dublin.*
1866. April 9	Forrest, John K., Esq., L.K.Q.C.P.I., F.R.C.S.I. 13, *Clare-street, Dublin.*
1874. Feb. 9	†Foster, Rev. Nicholas. *Ballymacelligott Rectory, Tralee.*
1838. Nov. 12	**Frazer*, George A., Esq., Captain R.N.
1866. May 14	Frazer, William, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 20, *Harcourt-street, Dublin.*
1865. April 10	†Freeland, John, Esq., M.D. *Antigua, West Indies.*
1847. May 10	*Freke, Henry, Esq., M.D. (Dub.), F.K.&Q.C.P.I. 68, *Mount-street, Lower, Dublin.*
1873. April 14	*†Frost, James, Esq., J.P. *Ballymorris, Cratloe, Co. Clare.*
1866. April 9	Gaffney, Rev. James. *Coolock, Co. Dublin.*
1859. Jan. 10	Gages, Alphonse, Esq., Chev. L.H., F.R.G.S.I. *Royal College of Science,* 51 *St. Stephen's-green, (East), Dublin.*
1845. April 14	*Galbraith, Rev. Joseph Allen, M.A., F.T.C.D., F.R.G.S.I. 8, *Trinity College, Dublin.*
1866. June 11	†Gallwey, Thomas, Esq., J.P. *Killarney.*
1864. Jan. 11	Garnett, George Charles, Esq., B.A. 5, *Mountjoy-square, (North), Dublin.*
1863. Feb. 9	*Garstin, John Ribton, Esq., M.A., LL.B., F.S.A., F.R. Hist. Soc., Hon. F.R.I.A.I., J.P., Treasurer of the Academy. *Green-hill, Killiney, Co. Dublin.*
1851. Jan. 13	Gibson, James, Esq., M.A., Q.C. 35, *Mountjoy-square, (South), Dublin.*
1855. April 9	*Gilbert, John Thomas, Esq., F.S.A., R.H.A., Librarian of the Academy. *Villa Nova, Blackrock, Co. Dublin.*
1874. April 13	†Goold, Ernest H., Esq., C.E. 35, *Lady-lane, Waterford;* 18, *Queen Victoria-street, London, E.C.*
1858. June 14	Goold, Ven. Frederick, M.A., Archdeacon of Raphoe. *University Club,* 17, *St. Stephen's-green, (North), Dublin.*
1875. April 12	†Gore, J. E., Esq., C.E. *Umballa, Punjaub.*

Date of Election.	
1836. May 25	*Gough, Right Hon. George S., Viscount, M.A., D.L., F.L.S., F.G.S. *St. Helen's, Booterstown, Co. Dublin.*
1848. June 12	*Graham, Andrew, Esq. *Observatory, Cambridge.*
1848. April 10	*Graham, Rev. William. *Dresden.*
1863. April 13	†Granard, Right Hon. George-Arthur-Hastings, Earl of, K.P. *Castle Forbes, Co. Longford.*
1837. April 24	*Graves, Right Rev. Charles, D.D., Lord Bishop of Limerick, &c. *The Palace, Henry-street, Limerick.*
1860. May 14	Graves, Rev. James, B.A. *Inisnag Glebe, Stonyford, Co. Kilkenny.*
1874. Feb. 9	Gray, William, Esq. 6, *Mount-Charles, Belfast.*
1867. April 8	Green, James S., Esq. Q.C. 83, *Leeson-street, Lower, Dublin.*
1872. April 8	†Greene, John Ball, Esq., C.E., F.R.G.S.I., Commissioner of Valuation. 6, *Ely-place, Dublin.*
1824. Mar. 16	*Grierson, George A., Esq. *Malahide, Co. Dublin.*
1819. April 26	*Griffith, Sir Richard, Bart., LL.D., F.R.S.Ed., F.G.S., V.P.R.G.S.I. 2, *Fitzwilliam-place, Dublin.*
1842. Jan. 10	*Grimshaw, Wrigley, Esq., F.R.C.S.I. 2, *Novara-terrace, Bray.*
1839. Jan. 14	*Grubb, Thomas, Esq., F.R.S. 141, *Leinster-road, Rathmines, Co. Dublin.*
1870. April 11	†Guinness, Sir Arthur E., Bart., M.A., M.P., D.L. 18, *Leeson-street, Lower; St. Anne's, Clontarf, Co. Dublin.*
1873, Dec. 8	*Guinness, Edward Cecil, Esq. M.A., D.L. 80, *St. Stephen's-green (South), Dublin.*
1836. April 25	*Hamilton, Charles William, Esq., J.P. 40, *Dominick-street, Lower, Dublin.*
1875. Jan. 11	Hamilton, Edward, M.D., F.R.C.S.I. 120, *St. Stephen's-green, (West), Dublin.*
1867. April 8	*Hanagan, Anthony, Esq. *Luckington, Dalkey, Co. Dublin.*
1847. Jan. 11	Hancock, William Neilson, Esq., LL.D. 64B, *Gardiner-street, Upper, Dublin.*
1850. April 8	*Hardinge, William Henry, Esq. *Woodlands, Rochestown-avenue, Monkstown, Co. Dublin.*
1837. Feb. 13	*Hart, Andrew Searle, Esq., LL.D., S.F.T.C.D. 71, *St. Stephen's-green, (South); Trinity College, Dublin.*
1874. Dec. 14	*Harvey, Reuben Joshuah, Esq., M.D. 7, *Merrion-street, (Upper), Dublin.*
1861. May 13	Hatchell, John, Esq., M.A., J.P. 12, *Merrion-square, South, Dublin.*
1857. Aug. 24	Hayden, Thomas, Esq., F.K.&Q.C.P.I., Prof. of Anatomy and Physiology, C.U.I. 30, *Harcourt-street, Dublin.*

Date of Election.	
1845. Feb. 24	*Haughton, Rev. Samuel, M.A., M.D., D.C.L. (Oxon.), F.R.S., F.G.S., F.R.G.S.I., F.K. & Q.C.P.I., Hon. F.R.C.S.I., F.T.C.D., Professor of Geology in the University of Dublin, a Vice-President of the Academy. 31, *Baggot-street, Upper, Dublin.*
1852. April 12	*Head, Henry H., Esq., M.D., F.K. & Q.C.P.I., Ex-F.R.C.S.I., F.R.G.S.I. 7, *Fitzwilliam-square (East), Dublin.*
1870. April 11	†Heily, John Vickers, Esq., M.D. *Lisaduran Cottage, Rushworth, Melbourne, Victoria.*
1840. June 8	*Hemans, George Willoughby, Esq., C.E., F.G.S. 1, *Westminster Chambers, Victoria-street, London, S.W.;* 17, *Gloucester-street, Upper, Dublin.*
1851. Jan. 13	*Hennessy, Henry, Esq., F.R.S., Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland, St. Stephen's-green, Dublin. *Mount Eagle, Sandyford, Co. Dublin.*
1865. Feb. 13	*Hennessy, William Maunsell, Esq. 11, *Gardiner's-place, Dublin.*
1871. Feb. 13	†Henry, Rev. P. Shuldham, D.D., President Q.C., Belfast. *Queen's College, Belfast.*
1873. Jan. 13	Hickie, James Francis, Lieut.-Col. (retired), J.P. *Slevoir, Roscrea, Co. Tipperary.*
1831. Mar. 16	*Hill, Lord George Augusta. *Ballyare House, Rathmelton, Letterkenny, Co. Donegal.*
1867. Feb. 11	†Hill, John, Esq., C.E., F.R.G.S.I. *County Surveyor's Office, Ennis.*
1875. Jan. 11	†Hill, Arthur, Esq., B.E., A.R.I.B.A. 22, *George's-street, Cork.*
1847. April 12	*Hone, Nathaniel, Esq., M.A., F.R.G.S.I., J.P. *St. Doulough's, Co. Dublin.*
1851. June 9	*†Hone, Thomas, Esq., J.P. *Yapton, Monkstown-avenue, Monkstown, Co. Dublin.*
1861. April 8	Hudson, Alfred, Esq., M.D., F.K. & Q.C.P.I., F.R.G.S.I. 2, *Merrion-square, North, Dublin.*
1824. Feb. 28	*Hudson, Henry, Esq., M.D., F.K. & Q.C.P.I. *Glenville, Fermoy.*
1875. June 11	†Hume, Rev. Abraham, Canon, D.C.L. *All Souls' Vicarage, Liverpool.*
1866. June 11	Hutton, Thomas Maxwell, Esq., J.P. 3, *Fitzwilliam-place, Dublin.*
1847. Jan. 11	*Ingram, John Kells, Esq., LL.D., F.T.C.D., Regius Professor of Greek in the University of Dublin, Secretary of Council of the Academy. 2, *Wellington-road, Dublin.*

Date of Election.	
1841. April 12	*Jellett, Rev. John Hewitt, B.D., S.F.T.C.D., F.R.G.S.I. 64, *Leeson-street, Lower, Dublin.*
1842. June 13	*Jennings, Francis M., Esq., F.G.S., F.R.G.S.I. *Brown-street, Cork.*
1867. April 8	Jephson, Robert H., Esq. *Mount Erroll, Donnybrook, Co. Dublin.*
1863. Jan. 12	Joyce, Patrick Weston, Esq., LL.D. 7, *St. Edward's-terrace, Garville-avenue, Rathgar.*
1870. Dec. 12	†Joyce, Robert D., Esq., M. D. 21, *Bowdoin-street, Boston, Mass., U.S., America.*
1831. Nov. 30	*Kane, Sir Robert, M.D., LL.D., F.K. & Q.C.P.I., F.R.S., F.R.G.S.I., F.C.S., a Vice-President of the Academy. 21, *Raglan-road, Dublin.*
1873. Dec. 8	*Kane, Robert Romney, Esq., M.A. 76, *Harcourt-street, Dublin.*
1865. April 10	Kane, William Francis De Vismes, Esq., M.A., J.P. *Drumreaske House, Monaghan.*
1869. June 14	Kavanagh, Very Rev. James B., D.D. *St. Patrick's College, Carlow.*
1870. June 13	*Keane, John P., Esq., C.E., Engineer, Public Works Department, Bengal. *Calcutta.*
1867. Feb. 11	Keane, Marcus, Esq., J.P. *Beech Park, Ennis;* 83, *Harcourt-street, Dublin.*
1864. Nov. 14	*Keenan, Patrick J., Esq., C.B., Resident Commissioner, Board of National Education, Ireland. *Delville, Glasnevin, Co. Dublin.*
1838. June 24	*Kelly, Denis Henry, Esq., J.P. *Araghty Grange, Fuerty, Roscommon.*
1870. May 23	*Kelly, John, Esq., L.M. (Dub.). *University College Hospital, Calcutta.*
1836. Jan. 25	*Kelly, Thomas F., Esq., LL.D., J.P. 10, *Newtown-smith, Kingstown, Co. Dublin.*
1869. Nov. 8	†Kelso, John Johnston, Esq., M.D., M. Ch. *Lisburn.*
1846. April 13	*Kennedy, James Birch, Esq., J.P. *Cara, by Killarney.*
1848. April 10	*Kenney, James Christopher F., Esq., J.P. *Clogher House, Ballyglass, Co. Mayo; Kilclogher, Athenry, Co. Galway;* 2, *Merrion-square, South, Dublin.*
1838. May 14	*Kent, William Toderick, Esq., M.A. 51, *Rutland-square, (West), Dublin.*
1874. May 11	†Kidd, Abraham, Esq., M.D. *Ballymena.*
1866. April 9	*Kinahan, Edward Hudson, Esq., J.P. 11, *Merrion-square, North, Dublin.*
1868. Jan. 13	Kinahan, George Henry, Esq., F.R.G.S.I. *Somerton, Wexford; Geological Survey Office,* 14, *Hume-street, Dublin.*
1863. April 13	Kinahan, Thomas W., Esq., B.A. 2, *Abercorn-terrace Circular-road, North, Dublin.*

Date of Election.	
1845. June 8	*King, Charles Croker, Esq., M.D., F.R.C.S.I. 1, *Belgrave-place, Cork.*
1837. Feb. 13	**Knox,* George J., Esq.
1835. Nov 30.	*Kyle, William Cotter, Esq., LL.D. 8, *Clare-st., Dublin.*
1864. April 11	*Lalor, John J., Esq., F.R.G.S.I. *City Hall, Cork-hill, Dublin.*
1875. May 10	†Lane, Alexander, Esq., M.D. *Ballymoney.*
1833. Nov. 30	*Larcom, Right Hon. Sir Thomas Aiskew, Bart., Major-General, K.C.B., R.E., LL.D., F.R.S., F.R.G.S.I., an Honorary Member of the Academy. *Heathfield, Fareham, Hants.*
1864. Jan. 11	LaTouche, J. J. Digges, Esq., M.A. 1, *Ely-place, Upper, Dublin.*
1836. Jan. 25	*LaTouche, William Digges, Esq., M.A., D.L. 34, *St. Stephen's-green, (North), Dublin.*
1857. May 11	*Lawson, Right Hon. James A., LL.D., Justice of the Court of Common Pleas. 27, *Fitzwilliam-street, Upper, Dublin.*
1857. April 13	*Leach, Lieut.-Colonel George A., R.E. 3, *St. James's-square, London, S.W.*
1839. May 13	*†Leader, Nicholas P., Esq., J.P. *Dromagh Castle, Kanturk.*
1852 May 10	Leared, Arthur, Esq., M.D. (Dub.), F.R.C.P. Lond., and Physician to the Great Northern Hospital. 12, *Old Burlington-street, London, W.*
1845. Feb. 10	*LeFanu, William R., Esq., C.E. 59, *Fitzwilliam-square, (North), Dublin.*
1846. May 11	*Lefroy, George, Esq. *(Abroad.)*
1844. April 8	*†Leinster, His Grace Charles-William, Duke of, Chancellor of the Queen's University in Ireland, and President of the Royal Dublin Society. *Carton, Maynooth.*
1828. April 28	*†Lenigan, James, Esq., M.A., D.L. *Castle Fogarty, Thurles.*
1869. April 12	*Lenihan, Maurice, Esq., J.P. *Limerick.*
1853. April 11	Lentaigne, John, Esq., C.B.. M.B., J.P., F.R.G.S.I. 1, *Denmark-street, Great, Dublin.*
1870. June 13	Leonard, Hugh, Esq., F.G.S., F.R.G.S.I. *Geological Survey of Ireland,* 14, *Hume-street, Dublin.*
1868. April 27	*Little, James, Esq., M.D., L.R.C.S.I., F.K.&Q.C.P.I. 24, *Baggot-street, Lower, Dublin.*
1832. Feb. 27	*Lloyd, Rev. Humphrey, D.D., D.C.L. (Oxon.), F.R.SS. Lond. and Edin., V.P.R.G.S.I., V.P.R.D.S., Member of the German Order "For Merit," Provost of Trinity College, Dublin. *Provost's House, Dublin; Victoria Castle, Killiney, Co. Dublin.*

Date of Election.	
1846. Jan. 12	*Lloyd, William T., Esq., M.D. *London.*
1875. April 12	Lombard, James F., Esq., J.P. *Southill, Rathmines, Co. Dublin.*
1845. Feb. 10	*Longfield, Rev. George, D.D., F.T.C.D. 1, *Earlsfort-terrace, Dublin.*
1838. Feb. 12	*†Longfield, Right Hon. Mountifort, LL.D. (late Judge in the Landed Estates' Court). 47, *Fitzwilliam-square, (West), Dublin.*
1868. Jan. 13	Lyne, Robert Edwin, Esq. *Sandymount, Co. Dublin.*
1851. May 12	*Lyons, Robert D., Esq., M.B., F.K. & Q.C.P.I., Prof. of Medicine, C.U.I. 8, *Merrion-square, West, Dublin.*
1873. April 14	Macalister, Alexander, Esq., M.B., L.R.C.S.I., L.K. & Q.C.P.I., F.R.G.S.I., Professor of Comparative Anatomy and Zoology in the University of Dublin. 15. *Palmerston-road, Upper Rathmines, Co. Dublin.*
1871. Feb. 13	*Macartney, J. W. Ellison, Esq., M.P., J.P. *The Palace, Clogher.*
1857. April 13	Mac Carthy, Denis Florence, Esq. 106, *Baggot-street, Lower, Dublin.*
1853 April 11	*McCarthy, James Joseph, Esq., R.H.A. *Charleston House, Rathmines, Co. Dublin.*
1875 Jan. 11	†Mac Carthy, John G., Esq., M.P. *Harbour View-Terrace, St. Luke's, Cork.*
1874. Feb. 9	McClure, Rev. Edmund, M.A. 67, *Lincoln's-Inn Fields, London, W.C.*
1873. Jan. 13	*McCready, Rev. Christopher, M.A. 29, *Grosvenor-road, West, Rathgar, Dublin.*
1864. April 11	*McDonnell, Alexander, Esq., M.A., C.E., F.R.G.S.I. *St. John's, Island-bridge, Co. Dublin.*
1825. Feb. 24	**Macdonnell,* James S., Esq., C.E.
1827. Mar. 16	*Mac Donnell, John, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 32, *Fitzwilliam-street, Upper, Dublin.*
1857. Feb. 9	*McDonnell, Robert, Esq., M.D., F.R.C.S.I., F.R.S. 14, *Pembroke-street, Lower, Dublin.*
1865. April 10	†Mac Donnell, Lieut.-Col. William Edward Armstrong, Vice-Lieutenant of the County Clare. *New Hall, near Ennis.*
1856. June 9	*Mac Ivor, Rev. James, D.D., F.R.G.S.I. *Moyle, Newtownstewart.*
1871. April 10	Macnaghten, Colonel Francis Edmund (Late 8th Hussars). *Lowther Lodge, Balbriggan.*
1831. Feb. 28	**Mac Neill,* Sir John, LL.D., F.R.S., F.R.A.S. 7, *Kensington-square, London, W.*
1874. April 13	McSwiney, Stephen Myles, Esq., M.D. 1, *Hume-street, Dublin.*

Date of Election.	
1846. Feb. 23	*Madden, Richard R., Esq., F.R.C.S. Eng. 1, *Vernon-terrace, Booterstown-avenue, Booterstown, Co. Dublin.*
1864. June 13	Madden, Thomas More, Esq., M.D., L.K.Q.C.P.I., M.R.C.S.E., L.F.P.S., Examiner in Midwifery, etc., Q.U.I. 33, *Merrion-square, South, Dublin.*
1870. Jan. 10	Mahaffy, Rev. John Pentland, M.A., F.T.C.D. 38, *George's-street, Great, North, Dublin.*
1874. Feb. 9	Malet, John Christian, Esq., M.A. *Trinity College, Dublin.*
1832. Oct. 22	*Mallet, Robert, Esq., M.A., M. Eng., Ph. D., M.I.C.E., F.R.S., F.G.S., F.R.G.S.I. 16, *The Grove, Clapham-road, London, S.*
1865. April 10	*†Malone, Rev. Silvester. *Kilkee.*
1859. Jan. 10	*Manchester, His Grace William-Drogo, Duke of. 1, *Great Stanhope-street, London; Kimbolton Castle, St. Neot's, Hunts; The Castle, Tanderagee.*
1828. Mar. 15	*Martin, Ven. John Charles, D.D., Archdeacon of Kilmore. *Killeshandra.*
1871. Jan. 9	Maunsell, George Woods, Esq., M.A., D.L., V.P. R.D.S. 10, *Merrion-square, South, Dublin.*
1840. Jan. 13	Mollan, John, Esq., M.D., F.K.&Q.C.P.I., F.R.G.S.I. 60, *Fitzwilliam-square, (North), Dublin.*
1861. Jan. 14	†Monck, Right Hon. Charles-Stanley, Viscount, G.C.M.G., Lieutenant of Dublin City and County. *Charleville, Bray, Co. Wicklow.*
1858. Jan. 11	**Montgomery*, Howard B., Esq., M.D.
1860. Jan. 9	Moore, Alexander G. Montgomery, Lieut.-Colonel, 4th Hussars. *India.*
1845. June 23	*Moore, David, Esq., Ph. D., F.L.S., Director of the Botanical Gardens, Glasnevin. *Glasnevin, Co. Dublin.*
1861. Jan. 14	Moore, James, Esq., M.D., M.R.C.S.E. 7, *Chichester-street, Belfast.*
1869. Feb. 8	*Moran, Most Rev. Patrick F., D.D., Bishop of Ossory. *St. Kyran's College, Kilkenny.*
1866. April 9	More, Alexander Goodman, Esq., F.L.S. 3, *Botanic View, Glasnevin, Co. Dublin.*
1874. Feb. 9	Moss, Richd. J., Esq. 78, *Kenilworth-square, Rathgar.*
1840. Feb. 10	*Napier, Right Hon. Sir Joseph, Bart., D.C.L., LL.D., Vice-Chancellor of Dublin University. 4, *Merrion-square, South, Dublin.*
1844. June 8	*Neville, John, Esq., C.E., F.R.G.S.I. *Jocelyn-street, Dundalk.*
1854. May 8	Neville, Parke, Esq., C.E. 58, *Pembroke-road, Dublin.*
1872. June 24	Nolan, Francis, Esq., A.R.I.A.I. *Ardeevin, Glenageary, Kingstown, Co. Dublin.*

Date of Election.	
1873. Jan. 13	Nolan, Joseph, Esq., F.R.G.S.I., Geological Survey of Ireland. 14, *Hume-street, Dublin.*
1846. Jan. 12	*†Nugent, Arthur R., Esq. *(Portaferry, Co. Down).*
1869. June 14	*O'Brien, James H., Esq. *St. Lorcan's, Howth, Co. Dublin.*
1869. June 14	O'Callaghan, John Cornelius, Esq. 1, *Rutland-street, Upper, Dublin.*
1875. Jan. 11	O'Callaghan, J. J., Esq., F.R.I.A.I. 21 *Cambridge-road, Rathmines, Co. Dublin.*
1867. June 10	O'Conor Don, The, D.L., M.P. *Clonalis, Castlerea, Co. Roscommon.*
1833. May 27	*O'Dell, Edward, Esq., J.P. *Carriglea, Dungarvan.*
1867. Jan. 14	O'Donel, Charles J. Esq., J.P. 47, *Leeson-street, Lower, Dublin.*
1865. Apr. 10	O'Donnavan, William J., Esq., LL.D. *University Club,* 17, *St. Stephen's-green, (North), Dublin;* 54, *Kenilworth-square, Rathgar, Co. Dublin.*
1869. Apr. 12	†O'Ferrall, Ambrose More, Esq. *Balyna, Enfield.*
1866. June 8	*O'Grady, Edward S., Esq., B.A., M.B., M. Ch., F.R.C.S.I. 105, *St. Stephen's-green, (South), Dublin.*
1867. May 13	†O'Grady, Standish H., Esq. 8, *Duke-street, St. James's, London, S.W.*
1866. June 25	O'Hagan, John, Esq., M.A., Q.C. 22, *Fitzwilliam-street, Upper, Dublin.*
1857. June 8	O'Hagan, Right Hon. Thomas, Baron. 34, *Rutland-square, (West), Dublin.*
1869. Apr. 12	O'Hanlon, Rev. John. *Presbytery, Exchange-street, Lower, Dublin.*
1866. Jan. 8	O'Kelly, Joseph, Esq., M.A., F.R.G.S.I., Geological Survey of Ireland. 7, *Warwick-terrace, Leeson Park, Dublin;* 14, *Hume-street, Dublin.*
1869. Apr. 12	O'Laverty. Rev. James, P.P. *Holywood, near Belfast.*
1844. June 10	*Oldham, Thomas, Esq., LL.D., F.R.S., F.G.S., Hon. F.R.G.S.I., Superintendent of the Geological Survey of India. *Calcutta.*
1871. Apr. 10	O'Looney, Brian, Esq., Professor of Irish, C.U.I. *Catholic University,* 85, *St. Stephen's-green, (South), Dublin.*
1861. June 10	*O'Mahony, Rev. Thaddeus, D.D., Prof. of Irish in Dublin University. 37, *Trinity College, Dublin.*
1870. Jan. 10	O'Reilly, Joseph P., Esq., C.E., Prof. of Mining and Mineralogy, Royal Coll. of Science, Dublin. 58, *Park-avenue, Sandymount, Co. Dublin.*
1866. June 11	O'Rourke, Rev. John. *Maynooth.*
1888. Dec. 10	*Orpen, John Herbert, Esq., LL.D. 58, *Stephen's-green, (East), Dublin.*

Date of Election.	
1870. Feb. 14	O'Shaughnessy, Mark S., Esq., F.R.S.L., Regius Prof. of English Law, Queen's College, Cork, and one of the Examiners, Q.U.I. 19, *Gardiner's-place, Dublin.*
1866. Jan. 8	O'Sullivan, Daniel, Esq., Ph. D. 9, *Eden-park, Sandycove, Kingstown, Co. Dublin.*
1839. June 10	*Parker, Alexander, Esq., J.P. 46, *Upper Rathmines, Co. Dublin.*
1873. Feb. 10.	Patterson, William Hugh, Esq. *Dundela, Strandtown, Belfast.*
1847. Feb. 8	*†Pereira [elected as Tibbs], Rev. Henry Wall, M.A., F.S.A. Scot.,&c. *Donnington Lodge, Iffley, Oxford.*
1872. Apr. 8	Phayre, Major-General Sir Arthur Purves, K.C.S.I., C.B., Governor of the Mauritius. "*Care of Messrs. H. S. King and Co., 45 Pall Mall, London, S.W.*"
1841. Apr. 12	*Phibbs, William, Esq. *Seafield, Sligo.*
1843. Dec. 11	*Pickford, James H., Esq., M.D., M.R.C.S E., D.L. 1, *Cavendish-place, Brighton.*
1863. Apr. 13	Pigot, David R., Esq., M.A. *Dundrum House, Dundrum, Co. Dublin.*
1870. Apr. 11	Pigot, Thomas F., Esq., C.E., Prof. of Descriptive Geometry, etc., Royal College of Science, Dublin. 4, *Wellington-road, Dublin.*
1838. Feb. 12	*Pim, George, Esq., J.P. *Brennanstown, Cabinteely, Co. Dublin.*
1849. Jan. 8	*Pim, Jonathan, Esq. *Greenbank, Monkstown, Co. Dublin.*
1851. Jan. 13	*Pim, William Harvey, Esq. *Monkstown House, Monkstown, Co. Dublin.*
1864. Jan. 11	*†*Poore*, Major Robert, (Late 8th Hussars). *(Abroad.)*
1862. Apr. 14	*Porte, George, Esq. 43, *Brunswick-street, Great, Dublin.*
1873. Jan. 13	*Porter, Alexander, Esq., M.D., F.R.C.S., Assist.-Surgeon, Indian Army. *Madras.*
1875. Jan. 11	†Porter, George Hornidge, Esq., M.D., Surgeon in Ordinary to the Queen in Ireland. 3, *Merrion-square, North, Dublin.*
1852. Apr. 12	**Porter*, Henry J. Ker, Esq.
1836. Apr. 25	*Porter, Rev. Thomas Hamblin, D.D. *Desertcreat, Tullahogue, Dungannon.*
1873. Jan. 13	Powell, George Denniston, Esq., M.D., L.R.C.S.I. 76, *Leeson-street, Upper, Dublin.*
1864. June 13	†Power, Sir Alfred, K.C.B., M.A., Vice-President of the Local Government Board for Ireland. 35, *Raglan-road, Dublin.*

Date of Election.	
1875. April 12	*†Powerscourt, The Right Hon. Lord Viscount. *Powerscourt, Enniskerry, Bray.*
1854. June 9	Pratt, James Butler, Esq., C.E. *Drumsna, County Leitrim*
1874. Dec. 14	*†Purcell, Mathew John, Esq. *(Burton, Co. Cork).*
1858. Jan. 11	Purser, John, jun., Esq., M.A. *Lota, Blackrock, Co. Dublin*; 6, *Mountpleasant, Belfast.*
1867. Jan. 14	*†Read, John M., General, U.S.; Consul-General of the U.S.A. for France and Algeria, Member of American Philos. Soc., Fellow of the Royal Soc. of Northern Antiquaries, &c. *Athens.*
1873. Feb. 10	*Readwin*, Thomas Allison, Esq., F.G.S., C.E.
1846. Dec. 14	*Reeves, Very Rev. William, D.D., M.B., LL.D., Dean of Armagh, a Vice-President of the Academy. *The Public Library, Armagh; Rectory, Tynan.*
1843. Feb. 13	**Renny*, Henry L., F.R.G.S.I., Lieut. R.E., (Retired List). [*Quebec.*?]
1875. Jan. 11	Reynolds, J. Emerson, Esq, M.D., Professor of Chemistry in the University of Dublin. 52, *Leeson-street, Upper, Dublin.*
1839. Apr. 8	**Rhodes*, Thomas, Esq., C.E., F.R.A.S., Hon. M.I.C.E.
1867. Apr. 8	Richey, Alexander George, Esq., LL.D., Q.C. 27, *Pembroke-street, Upper, Dublin.*
1855. Apr. 9	Ringland, John, Esq., M.D. (Dub.), F.K. & Q.C.P.I. 14, *Harcourt-street, Dublin.*
1816. Feb. 14	*Robinson, Rev. Thomas Romney, D. D., F. R. S., F.R.Ast.S., Hon.M.I.C.E.Lon., Hon.M.I.C.E.I., Hon. M. Cambridge Phil. Soc., Hon. M. Acad. Palermo, Hon. M. Acad. Philadelphia, Hon. F. R.G.S.I., Royal Medallist, R.S., 1862, Director of Armagh Observatory. *Observatory, Armagh.*
1844. June 10	*Roe, Henry, Esq., M.A. *(Isle of Man.)*
1870. Nov. 30	Rosse, Rt. Hon. Lawrence, Earl of, D.L., D.C.L., V.P.R.S., F.R. Ast. S. *Birr Castle, Parsonstown,*
1872. Apr. 8	†Rowley, Standish G., Esq., J.P., M.R.S.L. *Sylvan Park, Kells, Co. Meath.*
1868. Feb. 10	Russell, Very Rev. Charles William, D.D., President of the Royal College of St. Patrick, Maynooth. *The College, Maynooth.*
1843. Jan. 9	*Salmon, Rev. George, D.D., D.C.L. (Oxon.), LL.D. (Cantab.), F.R.S., and Royal Medallist, 1868, Regius Professor of Divinity in the University of Dublin. 81, *Wellington-road, Dublin.*
1853. Jan. 10	*Sanders, Gilbert, Esq. *Albany Grove, Monkstown, County Dublin.*

Date of Election.	
1851. May 12	*Sayers, Rev. Johnston Bridges, LL.D. *Velore, Madras.*
1848. Feb. 14	†Segrave, O'Neale, Esq., D.L. *Kiltimon, Newtown-mountkennedy.*
1846. Feb. 9	*†Sherrard, James Corry, Esq. *Kinnersley Manor, Reigate, Surrey.*
1873. Jan. 13	*†Shirley, Evelyn Philip, Esq., M.A., D.L., F.S.A. *Lough Fea, Carrickmacross; Lower Eatington Park, Stratford-on-Avon.*
1847. Jan. 11	*Sidney, Frederick J., Esq., LL.D., F.R.G.S.I., Secretary of the Royal College of Science, Dublin. 19, *Herbert-street, Dublin.*
1869. Apr. 12	Sigerson, George, Esq., M.D., M.Ch., F.L.S., Prof. of Botany, C.U.I. 17, *Richmond-hill, Rathmines, Co. Dublin.*
1861. Apr. 8	Sloane, John Swan, Esq., C.E. *Woodlands, Fairview, Co. Dublin;* 21, *Westmoreland-street, Dublin.*
1835. Feb. 23	*Smith, Aquilla, Esq., M.D., F.K. & Q.C.P.I., King's Prof. of Materia Medica and Pharmacy, Dub. Univ. 121, *Baggot-street, Lower, Dublin.*
1868. Jan. 13	†Smith, John Chaloner, Esq., C.E. *Engineer's Office, Dublin, Wicklow and Wexford Railway, Bray.*
1833. Apr. 22	*Smith, Joseph Huband, Esq., M.A.
1873. Jan. 13	Smyth, Patrick James, Esq., M.P., Chev. L. H. 15, *Belgrave-square, East, Rathmines, Co. Dublin.*
1867. Jan. 14	Smythe, William Barlow, Esq., M.A., D.L. *Barbavilla House, Collinstown, Killucan.*
1873. April 14	*Smythe, William James, Major-General, R.A., F.R.S. *Athenæum Club, London, S.W.*
1846. Apr. 13	*Stapleton, Michael H., Esq., M.B., F.R.C.S.I. 1, *Mountjoy-place, Dublin.*
1853. Apr. 11	*Stewart, Henry H., Esq., M.D., F.R.C.S.I. 75, *Eccles-street, Dublin.*
1874. Dec. 14	Stewart, James, Esq., M.A. (Cantab.), Professor of Greek and Latin, C.U.I. 21, *Gardiner's-place, Dublin.*
1871. June 12	Stokes, Whitley, Esq., LL.D., Secretary to the Supreme Council of India. *Legislative Council House, Calcutta.*
1834. Nov. 29	*Stokes, William, Esq., M.D., D.C.L. (Oxon.), LL.D. (Camb. and Dub.), F.R.S., F.K. & Q.C.P.I., Regius Prof. of Physic in the Univ. of Dublin, Member of the German Order "For Merit," PRESIDENT of the Academy. 5, *Merrion-square, North, Dublin.*
1874. June 22	Stokes, William, Jun., Esq., M.D., M.Ch. 3, *Clare-street, Dublin.*
1857. June 8	*Stoney, Bindon B., Esq., C.E., F.R.G.S.I. 42, *Wellington-road, Dublin.*

Date of Election.	
1856. Apr. 14	Stoney, George Johnstone, Esq., M.A., F.R.S., Secretary to the Queen's University in Ireland. *Weston, Dundrum, Co. Dublin.*
1857. Aug. 24	*Sullivan, William Kirby, Esq., Ph.D., President of Queen's College, Cork. *Queen's College, Cork.*
1874 Apr. 13	†Sweetman, H. S., Esq. 8, *Abbey Gardens, Abbey-road, St. John's Wood, London, N.W.*
1845. Feb. 24	*Sweetman, Walter, Esq., J.P. 4, *Mountjoy-square, (North), Dublin.*
1871. Jan. 9	†Symons, John, Esq. 72, *Queen-street, Hull.*
1845. June 23	*Talbot de Malahide, Right Hon. James, Baron, D.C.L., D.L., F.R.S., F.S.A., F.G.S., F.R.G.S.I., F.R. Hist. Soc., Pres. Archæol. Inst. *The Castle, Malahide, Co. Dublin.*
1848. Feb. 14	*†Tarrant, Charles, Esq., C.E. *Waterford.*
1863. Jan. 12	Taylor, Colonel Meadows, C.S.I., V.P.R.G.S.I. C.E., M.R.A.S., J.P. *Oldcourt, Harold's-cross, Co. Dublin.*
1846. Jan. 12	*Tenison, Colonel Edward King, M.A., Lieutenant of the County Roscommon. *Kilronan Castle, Keadue, Carrick-on-Shannon.*
1866. June 11	†Thom, Alexander, Esq., J.P. *Donnycarney House, Artane, Co. Dublin.*
1869. Apr. 12	Tichborne, Charles Roger C., Esq., F.C.S.L. 27, *Waltham-terrace, Blackrock, Co. Dublin; Apothecaries' Hall,* 40, *Mary-street, Dublin.*
1869. June 14	Tobin, Sir Thomas, F.S.A., D.L. *Ballincollig, Cork.*
1864. Mar. 16	Trench, Right Hon. and Most Rev. Richard-Chenevix, D.D., Lord Archbishop of Dublin, Primate of Ireland. *The Palace, St. Stephen's-green, (North), Dublin.*
1846. Feb. 9	*Tuffnell, Thomas Joliffe, Esq., F.R.C.S.I., M.R.C.S.E. 58, *Mount-street, Lower, Dublin.*
1816. Feb. 14	**Turner*, William, Esq.
1871. June 12	†*Tyrrell*, Colonel Frederick, J.P.
1868. Jan. 13	Urlin, Richard Denny, Esq. 12, *Leeson-park, Dublin.*
1834. May 26	*Vandeleur, Colonel Crofton M., D.L. 4, *Rutland-square, (East), Dublin,*
1870 Nov. 30	†Ventry, Right Hon. Dayrolles-Blakeney, Baron, D.L. *Burnham-house, Dingle, Co. Kerry.*
1836. Jan. 25	*Vignoles, Charles Blacker, Esq., Mem. Inst. C.E. Lond., F.R.S., F.R.A.S. 21, *Duke-street, Westminster, London, S.W.*

Date of Election.	
1873. Jan. 13	†Ward, Robert Edward, Esq., D.L. *Bangor Castle, Bangor, Belfast.*
1864. Feb. 8	*†Warren, James W., Esq., M.A. 39 *Rutland-square, (West), Dublin.*
1873. June 23	Warren, William H., Esq., M.D., L.R.C.S.I., L.K. & Q. C. P. I. 37, *Westland-row, Dublin; P. and O. Steam Nav. Co., Southampton.*
1866. Apr. 9	Westropp, W. H. Stacpoole, Esq., L.R.C.S.I., F.R.G.S.I., &c. *Lisdoonvarna, Co. Clare.*
1857. June 8	*Whitehead, James, Esq., M.D., F.R.C.S.E., M.R.C. Phys., Lon. 87, *Mosley-street, Manchester.*
1851. Jan. 13	*†Whittle, Ewing, Esq., M.D., M.R.C.S.E. 1, *Parliament-terrace, Liverpool.*
1874. June 8	Wigham, John R., Esq. 35, *Capel-street, Dublin.*
1839. June 10	*Wilde, Sir William Robert Wills, M.D., F.R.C.S.I., M.R.S. of Upsala, Surgeon Oculist to the Queen in Ireland. 1, *Merrion-square, North, Dublin.*
1862. Jan. 13	Wilkie, Henry, Esq. *Belgrave House, Monkstown-avenue, Co. Dublin.*
1873. April 14	†Wilkinson, Thomas, Esq. *Enniscorthy, Co. Wexford.*
1839. Jan. 14	*Williams, Richard Palmer, Esq., F.R.G.S.I. 38, *Dame-street., Dublin.*
1837. Jan. 9	*Williams, Thomas, Esq. 38, *Dame-street, Dublin.*
1866. Jan. 8	*Wilson, Henry, Esq., F.R.C.S.I. 29, *Baggot-street, Lower, Dublin.*
1844. June 10	*Wilson, Robert, Esq. 28, *Waterloo-road, Dublin.*
1855. Nov. 12	*Wright, Edward, Esq., LL.D. 16, *Hyde-Gardens, Eastbourne.*
1857. Aug. 24	Wright, Edward Perceval, Esq., M.A., M.D., F.L.S., Professor of Botany and Keeper of the Herbarium, Dublin University, F.R.C.S.I., Secretary of the Academy. *Herbarium, Trinity College, Dublin;* 50, *Lansdowne-road, Dublin.*

HONORARY MEMBERS.

Date of Election.	
1863. June 22	HIS ROYAL HIGHNESS ALBERT-EDWARD, PRINCE OF WALES.

"*The* PRESIDENT OF THE ROYAL SOCIETY, AND EX-PRESIDENTS *of the same, are always considered Honorary Members of the Academy.*"—By-Laws, ii., 14.

1869. Mar. 16 (Elected Hon. Mem. in Sec. of Science originally.)	Hooker, Joseph Dalton, M.D., C.B., F.R.S., D.C.L., LL.D., V.P.L.S., F.G.S., Director of the Royal Gardens, Kew, PRESIDENT OF THE ROYAL SOCIETY. *Kew, London, W.*
1863. Mar. 16	Sabine, General Sir Edward, R.A., K.C.B., D.C.L., LL.D., V.P. and EX-PRESIDENT OF THE ROYAL SOCIETY, Hon. F.R.S., Edin., F.R.A.S., F.L.S., &c. 13, *Ashley-place, Westminster, London, S.W.*
1832. Nov. 30 (Elected Hon. Mem. in Sec. of Science originally.)	Airy, Sir George Biddell, K.C B., D.C.L., LL.D., EX-PRESIDENT OF THE ROYAL SOCIETY (1871), Astronomer Royal, V.P. R. Ast. S., &c. *The Royal Observatory, Greenwich, London, S.E.*

SECTION OF SCIENCE.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

1873. Mar. 15	Adams, John Couch, LL.D., (Dub.) F.R.S. and Copley Medalist, V.P.R. Ast. S., F.C.P.S., etc., Director of the Observatory and Lowndsean Professor of Astronomy and Geology in the University of Cambridge. *Observatory, Cambridge.*
1874. Mar. 16	Berthelot, Marcelin Pierre Eugène. *Boulevard Saint-Michel,* 57, *Paris.*
1875. Mar. 16	Bertrand, Joseph. *Paris.*
1869. Mar. 16	Bunsen, Robert Wilhelm Eberard, Ph.D., For. Mem. R.S. *Heidelberg.*
1869. Mar. 16	Carus, Prof. Victor J. *Leipsic.*
1873. Mar. 15	Cayley, Arthur, LL.D.(Dub.), F.R.S., V.P. R. Ast. S., &c., Sadlerian Professor of Mathematics in the University of Cambridge. *Cambridge.*
1866. Mar. 16	Chasles, Michel, For. Mem. R.S. *Rue du Bac,* 62, *Paris.*
1866. Mar. 16	Clausius, Rudolph Julius Emmanuel, For. Mem. R.S. *Zurich.*
1875. Mar. 16	Cotta, Bernard von. *Freiburg.*

HONORARY MEMBERS—*Continued.*

SECTION OF SCIENCE—Continued

Date of Election.	
1873. Mar. 15	Dana, James Dwight, LL.D., &c., Professor of Geology and Mineralogy in Yale College. *Yale College, U. S., America.*
1866. Mar. 16	Darwin, Charles, F.R.S., &c. *Down, Beckenham, Kent.*
1869. Mar. 16	Daubrée, Prof. Gabriel Auguste. *Ecole des Mines, Paris.*
1863. Mar. 16	Dove, Heinrich Wilhelm, For. Mem. R.S. *Berlin.*
1841. Mar. 16	Dumas, Jean Baptiste, For. Mem. R.S., G.C.L.H., Secretáire perpétuel de l'Institut de France. *Rue St. Dominique,* 69, *Paris.*
1875. Mar. 16	Gray, Asa. *Cambridge, Mass., U. S., America.*
1864. Mar. 16	Helmholtz, Hermann Louis. *Heidelberg.*
1873. Mar. 15	Hofmann, August. Wilhelm, Professor of Chemistry in the University of Berlin. *Berlin.*
1874. Mar. 16	Huxley, Thomas Henry, M.D., LL.D., Fellow and Secretary of the R.S. *London.*
1864. Mar. 16	Hyrtl, Carl Joseph. *Vienna.*
1874. Mar. 16	Lamont, Johann, Von. *Munich.*
1864. Mar. 16	Le Verrier, Urbain Jean Jos. *A l'Observatoire, Paris.*
1852. Nov. 30	Regnault, Henri Victor. For. Mem. R.S. *Paris.*
1873. Mar. 15	Schimper, Wilhelm Philipp, Professor of Geology in the University of Strasburg. *Strasburg.*
1873. Mar. 15	Secchi, Padre Angelo, Director of the Astronomical Observatory at Rome, For. Mem. R. S. *Rome.*
1869. Mar. 16	Séquard, Charles Edouard Browne-, M.D., F.R.C.P., F.R.S. *Rue Gay-Lussac,* 28, *Paris.*
1873. Mar. 15	Stokes, George Gabriel, D.C.L., LL.D. (Dub.), Fellow and Secretary of the R.S., F.C.P.S., F.R.S.Ed., &c., Lucasian Professor of Mathematics in the University of Cambridge. *Lensfield Cottage, Cambridge.*
1842. Mar. 16	Wheatstone, Sir Charles, F.R.S., LL.D., K.L.H., &c. 19, *Park-Crescent, Regent's-park, London, W.*
1867. Mar. 16	Würtz, Adolph Charles, For. Mem. R.S. *Rue St. Guillaume,* 27, *Paris.*

(2 *Vacancies.*)

SECTION OF POLITE LITERATURE & ANTIQUITIES.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

Elected in the Department of Polite Literature.

Date of Election.	
1863. Mar. 16	Ebel, Hermann. *Leipsic.*
1869. Mar. 16	Gayangos y Arce, Don Pascual de. *London.*
1869. Mar. 16	Lassen, Christian, Ph.D. *Bonn.*
1849. Nov. 30	Lepsius, Karl Richard. *Berlin.*
1869. Mar. 16	Mommsen, Dr. Theodore. *Berlin.*
1866. Mar. 16	Motley, John Lothrop, Esq., D.C.L. *U.S., America.*
1863. Mar. 16	Müller, Professor Max. *Oxford.*
1850. Nov. 30	Thiers, Louis Adolphe. *Paris.*

Elected in the Department of Antiquities.

1869. Mar. 16	Benavides, Don Antonio. *Madrid.*
1848. Nov. 30	Botta, Paul Emile. *Paris.*
1863. Mar. 16	Cochet, L'Abbé Jean Benoit Désiré. *Rouen.*
1867. Mar. 16	De Rossi, Commendatore Giovanni Battista. *Rome.*
1863. Mar. 16	Keller, Ferdinand. *Zurich.*
1869. Mar. 16	*Larcom, Right Hon. Sir Thomas A., Bart., Major-General, K.C.B., F.R.S., &c. *Heathfield, Fareham, Hants.*
1854. Mar. 16	Mauray, Alfred. *Paris.*
1866. Mar. 16	Nillssen, Rev. S. *Copenhagen.*
1841. Mar. 16	Phillipps, (*late* Halliwell,) James Orchard, Esq., F.R.S., F.S.A. Lond. and Edin., &c. 11, *Tregunter-road, South Kensington, London, S.W.*
1867. Mar. 16	Visconti, Barone Commendatore P. E. *Rome.*
1867. Mar. 16	Worsaae, Prof. Hans Jacob Asmussen. *Copenhagen.*

Elected since the union of the two classes of Honorary Members in this Section.

1875. Mar. 16	Franks, Augustus Wollaston, M.A., F.R.S., F.S.A. 103, *Victoria-street, London, S.W.*
1875. Mar. 16	Hardy, Sir Thomas Duffus, D.C.L., Deputy-Keeper of the Public Records, England. 35, *North-Bank, Regent's-Park, London, N.W.*
1873. Mar. 15	Longfellow, Henry Wadsworth. *Cambridge, Mass., U. S., America.*
1873. Mar. 15	Nigra, His Excellency Cavaliere Constantino, Italian Minister to France. *Paris.*
1875. Mar. 16	Pictet, Adolphe. *Geneva.*
1875. Mar. 16	Stuart, John, LL.D., F.S.A. Scot. *Edinburgh.*
1873. Mar. 15	Westwood, John Obadiah, Esq., F.S.A. *Oxford.*
1875. Mar. 16	Whitney, William Dwight. *Yale College, Connecticut, U.S., America.*

(3 *Vacancies.*)

SUMMARY.

Life Members	...	...	...	197
Annual Members	...	...	...	174
				371
Honorary Members (4 + 55) ...			...	59
		Total,	...	430

Should any errors or omissions be found in this List, which is revised to 1st of September, 1875, it is requested that notice thereof may be given to the Secretary of the Academy. He should also be informed of the death of any Member.

As this list will be kept standing in type, it can be readily corrected from time to time.

R. D. Webb and Son, Printers, 74, Middle Abbey-street, Dublin.