THE

TRANSACTIONS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXXIII

DUBLIN

PUBLISHED BY THE ACADEMY

AT THEIR HOUSE, 19, DAWSON STREET

1906–1907

THE ACADEMY *desire it to be understood that they are not answerable for any opinion, representation of facts, or train of reasoning that may appear in the following Papers. The Authors of the several Essays are alone responsible for their contents.*

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The Academy.

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VOLUME XXXIII., SECTION A, PART I.

A. L. CORTIE

THE TOTAL SOLAR ECLIPSE OF 1905

REPORT OF THE STONYHURST COLLEGE EXPEDITION TO VINAROZ, SPAIN

(PLATES I., II.)

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Section A—Mathematical, Astronomical, and Physical Science.

Section B—Biological, Geological, and Chemical Science.

Section C—Archæology, Linguistic and Literature.

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BY THE REV. A. L. CORTIE, S.J., F.R.A.S.

ERRATA.

Page 22, Diagram. The position (1) ought to be as far removed to the left of C as it is placed to the right.

Page 23. In the Table, Spot 1, *for* 'Longitude + 350°' *read* 'Longitude + 330°'.

Page 24, line 12. *For* '31° removed' *read* '51° removed'.

Aug. 30, crossed some fifteen colleges and residences of the Jesuits in Spain, from Gijon, on the north coast, to the newly-erected observatory for the study of cosmical physics at Tortosa, near the mouth of the River Ebro, on the Mediterranean coast. As several of these colleges, and others not on the line of totality, are exceedingly well equipped with apparatus for the teaching of physics, it was determined to organize joint expeditions of the professors and others to occupy points of vantage on the track of totality, so as to secure as complete observations of the eclipse as the instrumental means would allow. The general direction and organization of the

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Read APRIL 23. Ordered for Publication MAY 7.
Published AUGUST 31, 1906.

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1. ORIGIN OF THE EXPEDITION.

THE track of the Moon's shadow, during the total solar eclipse of 1905, Aug. 30, crossed some fifteen colleges and residences of the Jesuits in Spain, from Gijon, on the north coast, to the newly-erected observatory for the study of cosmical physics at Tortosa, near the mouth of the River Ebro, on the Mediterranean coast. As several of these colleges, and others not on the line of totality, are exceedingly well equipped with apparatus for the teaching of physics, it was determined to organize joint expeditions of the professors and others to occupy points of vantage on the track of totality, so as to secure as complete observations of the eclipse as the instrumental means would allow. The general direction and organization of the

eclipse parties were under the charge of Father Richard Cirera, S.J., the Director of the Tortosa Observatory; and invitations were despatched to Jesuit astronomers of other nationalities to co-operate in the observations. A very useful and opportune brochure, and one quite exhaustive of the subject, "Instructions pour l'observation de l'éclipse totale de Soleil du 30 Août 1905" (Tortosa, Imp. de José L. Floquet, 1905), was drawn up by Father John Stein, S.J., Doctor in Astronomy, and was circulated widely among possible observers. The Stonyhurst Observatory staff was favoured by a pressing invitation to come to Tortosa to observe the eclipse —an invitation which was gladly accepted. About the same time the late Dr. C. J. Joly, Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland, in an informal letter to Father Cortie, mentioned the fact that he himself was about to proceed to South Africa with the British Association, and that other members of the Royal Irish Academy were prevented by various reasons from taking part in an eclipse expedition. He suggested the probability of a favourable hearing of a formal request to the Royal Irish Academy for the loan, for eclipse purposes, of the cœlostat and long-focus lens which he himself and Sir Howard Grubb, F.R.S., had used in the eclipse of 1900, May 28th. The request was despatched through Professor Joly, the then Secretary of the Academy, and most graciously acceded to. We wish again to record our thanks to the Council of the Royal Irish Academy for their kind courtesy, and, as some token of our gratitude, we have asked them to honour us by allowing us to lay before them the results of our observations taken with their instruments. The present report is the witness of our obligations, and is presented in discharge of our indebtedness to the members of the Academy. The suggestion of applying for the loan of the instruments, and the kindly influence exerted in obtaining a favourable answer, are not the only services for which the expedition is beholden to the late Professor C. J. Joly. In addition, he evinced the keenest interest in the success of the expedition, and for this end wrote several long letters detailing his experiences with the instruments in the 1900 eclipse, giving valuable hints as to the mounting and adjusting of the cœlostat, warning the observers as to the danger of dust and wind on the cœlostat, and finally, stating the best

position relatively to the visual focus for the sharpest photographic focus of the lens, as determined by his own experiments. The hints and instructions he gave were of great practical use when we came to the selection of a suitable site for the instruments, and especially so in obtaining the sharp focus of our photographs. It is a melancholy satisfaction to be able to add that he was so kind as to dictate a card, a few days before he died, expressing his appreciation of our photographs, prints from which had been sent to him.

The cœlostat and long-focus lens arrived at Stonyhurst at the beginning of the month of June, and were erected temporarily in the college gardens, so that we might become familiar with the adjustment and working of the instruments. At the same time, two spectrographs were fitted up from materials already existing at the observatory, due largely to the ingenuity of Mr. Joseph Ronchetti. All the instruments were packed and despatched from Liverpool for Barcelona on July 15th, by the steamship "Jacinta," of the Serra and Tintore Steamship Company's fleet, so as to avoid all risk, if possible, of their non-arrival in time for the eclipse at their destination in Spain. They had previously been insured at a very reasonable rate with the Indemnity Mutual Marine Assurance Company. We are indebted to Mr. Lewis, of the Serra and Tintore Steamship Company, for the especial care and trouble he took to see that the instruments were safely delivered at Barcelona, as also to Professor E. T. Whittaker, F.R.S., the then Secretary of the Royal Astronomical Society, for informing the Spanish authorities of the despatch of the equipment, so that it should enter Spain duty free. Except for the expenses connected with the instruments, the whole financing of the expedition was very generously undertaken by Mr. John Liddell, of Sydmonton Court, Newbury, his son, Mr. Aidan Liddell, a pupil of Father Cortie, accompanying him as his chief assistant.

2. SELECTION OF A STATION AND ITINERARY.

It had been our original intention to set up our instruments at the observatory of Tortosa, the advantages of having a site near a fixed observatory being manifold. On the other hand, had we done so, we should have

lost more than a minute of the possible duration of totality, 3·7 minutes, the duration of totality at Tortosa being 2·6 minutes. Moreover, expeditions from Jesuit colleges in Portugal, Belgium, and Holland were already intending to view the eclipse at Tortosa, in addition to a French Government party from Lyons, under the direction of M. André. Former experience has shown the desirability of scattering the observers, if success in eclipse operations is to be secured. As the event proved, while our expedition had fine weather during totality, the parties at the Tortosa Observatory lost one minute due to bad weather; the French party at the base of the mountain missed the whole eclipse for the same cause; a misfortune which equally befell the English Government party from South Kensington, situated about as far west of our camp as Tortosa was east. For these reasons application was made to Father Cirera to ascertain if it would be possible to place ourselves at a situation nearer the central line of eclipse. He very kindly interested himself in the matter, and in due course informed us that arrangements had been made for us to go to Vinaroz, on the Mediterranean coast of Spain, where the inhabitants of the town were prepared to welcome us most warmly. On the receipt of this information instructions were sent to Vinaroz for the building of a pier for the cœlostat, and the making of a long wooden tube for the lens, to form the body of the camera. Nothing, however, was done until we arrived; happily so, as the sequel proved.

Father Cortie and Mr. Aidan Liddell left Birkenhead on the night of August 3rd, by the mail steamship "Warwickshire" of the Bibby Line, and arrived at Marseilles in the early hours of Friday, August 11th. The managers of the Bibby Line had courteously arranged that their agent should secure the transhipment of the cases containing our theodolite and other portable instruments to the steamship "Lederer Sándor" of the Adria Line, which left Marseilles for Barcelona on the evening of August 12th. While at Marseilles the observatory was visited under the guidance of the courteous director, M. Stefan, one special object of interest being the ingeniously-mounted comet-seeker with which M. Borrelly has made so many discoveries. Barcelona was reached on the evening of the following day, August 13th, and the warmest of

welcomes was tendered to the two members of the expedition by the Fathers of the fine day-school conducted by the Jesuits in the city. The heavy cases of instruments had arrived at Barcelona some few days previously to the arrival of the observers; these were secured and despatched at once to Vinaroz. Leaving Barcelona on the morning of August 15th, Tortosa was reached the same afternoon. There was much to interest us at Tortosa, the newly-erected observatory for the study of cosmic physics being very finely equipped in the departments of astronomy, spectroscopy, terrestrial magnetism, atmospheric and terrestrial electricity, seismography, and meteorology; and, in addition to the permanent equipment of the observatory, preparations were being made for mounting the eclipse instruments which other astronomers were bringing with them. The students of philosophy and theology, who were luckily in vacation, had been impressed into the service of astronomy as assistants for the nonce, and were busily engaged in practices for the eclipse. In all, some eighty Jesuits were gathered at Tortosa to observe the phenomenon. Father Cirera, the director of the observatory, though already fully occupied, found time to show us through the establishment and explain the uses of the instruments; and seeing that he made a part of his astronomical studies at Stonyhurst, the pleasure of our meeting was greatly enhanced. We are also much indebted to him for having personally gone to Vinaroz to make matters smooth for us when we should arrive at our destination. We ourselves reached the town on the afternoon of Wednesday, August 16th, travelling from Tortosa in company with His Grace the Archbishop of Granada, the Most Rev. Joseph Meseguer y Costa, who was about to pay a visit to his native place, and whose gracious kindness and urbanity to us during our stay in Vinaroz were of the greatest possible advantage to our party. The whole town was *en fête* to receive His Grace, and, after the reception, we immediately looked about for a site for our instruments; for we found that, in spite of instructions sent out from England, nothing at all had been prepared, and we, unused to eclipse operations, and isolated from all other parties, had just a fortnight in which to prepare everything for the day of eclipse. It was fortunate that nothing had been prepared, for

the first eligible site pointed out to us was the flat roof of a factory, the next a yard bricked over, radiating intense heat, and adjacent to an exceedingly dusty road—we were informed that no rain had fallen in the vicinity for about six months, and that the Bishops had ordered prayers for rain—the third, the top of a mountain, some six kilometres from the town, an ideal site for a permanent observatory, but too far removed from the town for an eclipse camp. We had almost determined to return to Tortosa, when Dr. Sebastian Roca most generously invited us to occupy his house as our temporary quarters, he meanwhile sending his family to his country house. This town house adjoined a field of lucerne, which seemed admirably suited for the erection of the instruments, and which was kindly placed at our disposal by Señor Don J. B. Pascual Esperanza. Only one more difficulty connected with the proposed site for the instruments remained, and that was that a high wall separated it from access to the garden of Dr. Roca's house. But Dr. Roca most accommodatingly offered to make a breach in the wall, so that there was easy communication between the house and the field. Señor Don Juan Faro was engaged as interpreter, and rendered invaluable services to us during the fortnight's stay in the town, as but very few of the inhabitants spoke French, and we were ignorant of Spanish. We were also much beholden to the kind offices of the Alcade Señor Don Juan Morales, who put a guard over our instruments day and night, the Archpriest, the Rev. Pascual Bono, and the local clergy; and to the Señors Don Juan Costa, Don Juan Ribera, Don Juan B. Sendra, Don Sanjuan, and many others. In fact, we personally, and our doings at the camp, were the objects of the keenest sympathy and interest to the generous and courteous inhabitants of this small town. We also established very friendly relations with Señor Don Comas y Sola, the director of the Fabra Observatory at Barcelona, and his assistants, who, arriving a week after our own coming, erected their instruments in another part of the town, as also with Professor Goeckel, of Fribourg, who set up an installation, for observing the variation in the electric potential of the atmosphere during the time of eclipse, upon the neighbouring mountain.

3. *The Site and the Instruments.*

The town of Vinaroz, according to the "Coordenadas Geográficas de puntos comprendidos en la zona de la totalidad del Eclipse de Sol de 30 de Agosto de 1905," issued by the Dirección general del Instituto Geográfico y Estadístico (Madrid, 1905), is situated in latitude 40° 28′ 15″·04, and longitude E. of Madrid 4° 9′ 44″·53, and as the cœlostat-pier was placed about a quarter of a mile south-west of the pillar on the tower of the parish church, which was the position of which the coordinates are given above, the coordinates of our situation may be taken as approximately

Latitude, . . . 40° 27′ 23″ N.
Longitude, . . . 1^{m} 51^{s} E. of Greenwich.

Besides the cœlostat and lens belonging to the Royal Irish Academy, three spectrographs were taken out, and a rather ambitious programme of observations was attempted, too ambitious as the sequel proved, considering that the assistants were not expert astronomers used to spectroscopic observations, and that this was the first experience of the leader of the party in eclipse operations. The present communication will be confined entirely to a description of the erection of the instruments belonging to the Academy, and the results obtained by their use. The very efficient form of cœlostat employed has already been fully described in Sir Howard Grubb's Report of the Total Solar Eclipse of 1900. It would, however, be an improvement, and aid considerably to a nice setting for latitude, if a small screw-jack were used below the clock, as experience showed that when held by hand, and the screws which permitted the clock to be raised or lowered were loosened, it was apt to move in jerks. Moreover, there is no theodolite furnished with the instrument to sit upon the polar axis. At Vinaroz the cœlostat was very solidly mounted on a pier of concrete and brick, which was built on the solid rock, at a depth of about one and a half metres below the soil. The dimensions of the pier, which was placed with its longer axis in the meridian, were 31 inches in height above the ground, 34 inches long, and 20 inches broad. A thick wooden slab of seasoned wood, about 3 inches thick, was placed on top of the brick-work, and solidly fastened into it by four long iron clamps bent twice at

right angles, which were screwed into the lower side of the wooden slab, the other ends being fastened into the brickwork. The meridian having been determined by observations of the Sun with a theodolite, the cœlostat was placed in the meridian line on the slab, and bolted to it by long wood screws passing through its three levelling-screws. A box had been constructed at Stonyhurst, and was used for packing the apparatus *en route*, which could be placed over the cœlostat, and rest on the wooden slab securely, by three iron staples which fitted into holes drilled to receive them. This box was covered with canvas soaked in boiling linseed oil, and afterwards painted white, so that the cœlostat was protected from the weather, without the necessity of constructing a hut to cover it. The cord, which was fastened to the weights to drive the clock, passed from the winding-drum of the clock through an aperture in the box, and then under a large iron pulley screwed to the wooden slab. Thence it passed over another large iron pulley hung at the top of a stout pole about 7 feet high, and was attached to a weight of about 60 kilograms. Having no theodolite fixed to the cœlostat, the triangular base of our heavy theodolite was removed, and a brass adapter was made by Señor Don Juan B. Sendra to fit the axes of the cœlostat and the theodolite. Necessarily there was a considerable amount of flexure on account of the weight of the theodolite, but the adjustment for latitude was satisfactorily made by this means, the final adjustment, on the days preceding and the day of the eclipse, being accomplished by means of the levelling-screws of the instrument, the image of a spot on the Sun being kept steadily for an interval of time, more than sufficient, on a diagonal line drawn on the ground-glass of the camera. Bearing in mind the warnings of Professor Joly with regard to the dangers of dust and wind, the position selected was admirably adapted to avoid these contingencies as far as possible. The instrument was protected from wind on two sides of the field, where it was situated, by high walls, and on the other two sides by a magnificent crop of very tall maize, so that when the wind blew in from the sea, their heads bent gracefully, while the cœlostat remained without the slightest tremor. The altitude of our camping-ground was only 5·85 metres above sea-level. The fact that the cœlostat pier was placed in a field of luxurious lucerne,

which was cut down, indeed, to allow freedom of movement, but the roots of which remained, and sent out shoots about a foot in height during our stay, was a preservative against dust, and, moreover, radiation from a heated soil was avoided, which would probably have seriously deformed the mirror, the normal shade temperature during our sojourn in the town being about 90° F. Also the clock was covered by a light box made by fixing lengths of thick cardboard together. In spite of all these precautions, however, such was the dusty nature of the place, particles of dust effected their entrance into the clock, and caused us at one time serious anxiety and trouble.

The body of the long wooden camera was made at Vinaroz by the local carpenter, Señor Don Sebastian Bover, whose resourceful ingenuity was placed entirely at our service. We were exceedingly fortunate in finding such a clever, willing, and genial assistant in the erection of our instruments. The material of the camera was pitch-pine soaked well in oil, and we experienced no trouble from warping due to heat, such as was experienced by Professor Joly in the 1900 eclipse. A shelf protruded from the under side of the long box, and on this rested another shelf to which an upright slab of wood was screwed containing the lens. The upper part of the vertical slab was clamped to the camera by two iron clutches, the end of the camera being lined with black plush to exclude all light. The lens in its wooden holder was thus easily detached and carried inside the house, after the work of the day, for safety. Similarly the ground-glass and the bellows at the other end of the long camera-box were attached by four slotted guides running over clamps. This part of the camera had been made in England before starting on the expedition. To avoid any danger from shaking, the camera was mounted on carpenter's trestles loaded with lead, and heavy iron ties from railway-sleepers were placed on top. Also on the day of the eclipse two or three seconds were allowed to elapse after drawing the slide before the lens was uncovered for an exposure. A fortnight was all too short for setting up and adjusting the instruments, and holding the necessary rehearsals. Accordingly, the experiments to determine the best photographic focus of the lens were incomplete when the day of eclipse arrived. But, acting on

the recollection of Professor Joly with regard to the point, the instrument was accurately focussed on the sun-spots visible on the Sun on the day of eclipse, and then the ground-glass was moved in a quarter of an inch. This important piece of work was undertaken by Mr. Louis Cafferata, and with perfect success, as the photographs are admirably focussed. We have entered into details somewhat minutely in regard to the erection of the cœlostat and camera, in view of the probability of the instruments being used in subsequent eclipses. Future observers with these instruments will in all likelihood be glad, as we were, to learn from the experience of the past.

4. THE DAY OF THE ECLIPSE. VISUAL OBSERVATIONS.

About a week before the day of the eclipse the two observers from Stonyhurst were joined by a former pupil of Father Cortie, in the person of Mr. Gonzalo de Aguilera, while yet another old Stonyhurst boy and former pupil of Father Cortie, Mr. Louis Cafferata, who rendered invaluable services to the expedition, joined us two days before the eclipse. There arrived with him also Father Augustin Morford, of Saltash, Cornwall, who brought a four-inch refractor with which he intended to make visual observations of the prominences and corona. This we mounted, on the morning of the eclipse day, on an empty wine-barrel. Canon Pitts, Rector of Loughborough and Honorary Canon of Peterborough, was also a spectator of the eclipse phenomena in our camp. The disposition of the observers was as follows:—Father Cortie called the seconds from the beginning of totality by the aid of a metronome, and took charge of the mirror and grating spectrograph; Mr. Louis Cafferata had charge of the transmission-grating and quartz-lens camera; and Mr. Gonzalo de Aguilera of a two-prism direct-vision photographic slit-spectroscope; Father Morford gave the signals "Go" and "Close" at the beginning and end of totality. To Mr. Aidan Liddell was entrusted the important charge of making the exposures with the twenty-foot camera. Dr. Roca was stationed near the lens, and had one end of a long string attached to his hand, the other end being pulled by Mr. Aidan Liddell as a signal to uncover and cover the lens for each

exposure. The slides containing the plates were wrapped in dark cloth and handed to Mr. Liddell by Señor Don Ribera, and received after exposure and wrapped again in dark cloth by Señor Don Costa. The following was the programme successfully carried out for the exposure of the plates, the camera working at *f*/ 60.

No.	Brand of Plate.	Speed: H. & D. Scale.	Exposures: Seconds.
1	Imperial Ordinary Backed, . .	88	4
2	Imperial Ordinary Backed, . .	88	8
3	Schleussner's Rapid Observatory, .	—	15
4	Schleussner's Rapid Observatory, .	—	50
5	Imperial Ordinary Backed, . .	88	15
6	Imperial Ordinary Backed, . .	88	6

The exposures, fifteen and fifty seconds, were specially chosen to compare the results with the like exposures made with the same instruments by Professor Joly in 1900. With regard to Dr. Schleussner's Rapid Observatory Plates, tests made with three different batches gave the Watkins numbers 90, 86, 100; but the maker declares that the speed number is misleading, and should be very much higher than the figures given. The first contact of the Moon with the Sun's western limb took place in a cloudless sky; but about half an hour after contact a great bank of black clouds began to form in the south-west, possibly caused by the gradual fall in temperature, and rose higher and higher towards the Sun. Detached filmy clouds next began to float across the Sun's face, and from these we were never free except for the last few seconds of eclipse. Long even before first contact, all the flat roofs of the houses all over the town, had been occupied by a cheering crowd, composed of the inhabitants of Vinaroz, and visitors from Barcelona and other neighbouring towns. To add to the din of the spectators, bombs to dissipate the great cloud-bank were sent up at intervals from the camp of the Barcelona observers. As the Moon advanced across the Sun's disc, the fall in temperature was very obvious, as also the coming of the eclipse-wind.

The birds also flew hurriedly to shelter, and the darkness was very similar to that caused by the smoke of a great conflagration. About five minutes before totality, Father Cortie put up his hand, and called "Silencio" in a loud voice to the spectators assembled on the house-tops immediately overlooking the observatory-field. This request was at once most courteously complied with, and the ticking of the metronome was now audible above the distant hum of conversation from those packed on the roofs of the houses in other parts of the town. Father Morford gave the signal "Go," and the clicking of the camera-slides seemed to show that everything was going well. The darkness was not very great—not equal to that of the landscape when the Moon is full; and there was no necessity at all for the lamp that had been lit to enable the chronometer to be seen. In the intervals of making the exposures I was able to get good glimpses of the eclipsed Sun with the naked eye, and with a low-power opera-glass and Thorp transmission-grating fixed in front of one of the eye-pieces. The most striking phenomenon of the eclipse, viewed visually, was the intense brightness of the lower or inner corona, which surrounded the black Moon in the form of a uniformly brilliant ring of light, extending apparently some 5′ or 6′ from the Moon's periphery. It was judged to be brighter than the full Moon. Viewed with the opera-glass and transmission-grating, it gave a very bright continuous spectrum, so bright as entirely to mask the green coronal-ring. Probably the brilliancy was enhanced by the light scattered from the filmy clouds which drifted across the eclipsed Sun. The photographs, too, of the spectrum of the corona show the continuous spectrum as extending from the ultra-violet to beyond D_3, that is over the whole extent of spectrum which the plates employed, Mawson Orthochromatic Plate B, were capable of photographing. The prominences appeared of a deep crimson colour, my impression being that they were very like the colour of the bright C-line in the solar spectrum. There were three main groups of streamers visible which looked like luminous, filmy-white daggers fixed on to the lower corona. They were placed roughly, as the Sun was viewed at Vinaroz, north-east, north-west, and south-west. The one that particularly attracted my attention, and therefore was presumably the brightest, was that on the

north-west. In length I estimated it to be one-half a lunar diameter. The re-appearance of a small spot of Sun-light was greeted with deafening cheers and hand-clapping by the assembled spectators; and whereas the coming on of darkness had been gradual, its dissipation seemed to be almost instantaneous. This is doubtless a physiological effect due to contrast. The plates were immediately packed, as they were, in the slides, in dark cloth, and securely placed in a box to be carried to Stonyhurst for development. It was twelve days before they were developed with great skill by Mr. William M'Keon, assistant at the observatory. Future observers, however, must be warned that it is a mistake to leave plates in the plate-holders when they are to be transported for some time before development. The plates must be withdrawn from the holders and packed in light-tight bags, such as those of Tylar, if they are to be preserved from fog due to the exhalation from the black material with which the interior of the slides is stained. We nearly lost four of our plates on this account, and in the case of at least two could not push the development as far as we otherwise would have wished. The grain of the wood appears decidedly on negatives II., III., and IV., although luckily it can easily be printed out. There is yet one more point with regard to the visual observations to be recorded, and that is, that the time of totality was nearly 11 seconds less than the calculated and published value for our station. Father Morford's Report is appended to complete the account of the visual observations.

5. REV. AUGUSTIN MORFORD'S REPORT.

I, having brought the only telescope, a refractor of $4\frac{5}{16}$ inches, and intending to make only visual observations, was appointed to give order to open and close cameras at the beginning and before the close of totality. My own observations were made with an eye-piece × 70, field 52′, with two crossed spider-threads, dividing the field into four quadrants.

Monday and Tuesday were cloudy in the afternoons—a presage of what we were to experience on the Wednesday. Tuesday was a choking day of hot south wind—a veritable sirocco—which in the afternoon grew violent, and raised clouds of dust. At evening we had a thunderstorm, but without

rain. The weather-wise prophesied perfect weather for the next day. Wednesday began auspiciously. The Sun shone, and the clouds were dissolved in the warm air, though overhead, at a great height, some were thickening.

First contact was observed at 11.54. It had already taken place a minute or two. I watched several Sun-spots as they passed under the black disc of the Moon. They did not differ sensibly in colour, observed with a prism and a green glass. Now began our anxieties. A cone of cloud was rising slowly from the south-west. At twenty minutes before totality our chance of an untroubled view did not seem great. As I had to announce totality, I paid great attention to Baily's beads. This phenomenon differed considerably from that of 1900. As then, I noticed the abscission and subsequent disappearance of the terminal portion of the southern part of the crescent. Mr. Chambers has quoted in his Astronomy Halley's description of this in 1715. A second time there was a division, again at the south end, but less distinct. The crescent fined down very much. A little way from either end it became narrower than at the ends themselves. They appeared almost lance-headed, slightly diffused on the edges. The running together of the beads was much less pronounced than in 1900. There were two remaining at a slight distance from each other—that to the south disappeared first.

I had been observing too closely during the last few minutes to pay attention to the clouds, and I had seen Baily's beads so distinctly that I never thought there could be any. But I slipped off the green glass, and it was evident something was wrong. The black disc of the Moon stood out forward. Behind there was a bright but diffused light, which seemed to come from behind the Moon. But no coronal detail could be seen, nor in the telescope did I see any the whole time. However, I had no time to lose. The chief thing I intended to do was to map down the positions of the prominences, red, white, or pale tint, with coloured chalks. Five splendid prominences were glowing brilliantly in the north-east quadrant. I had grey writing-paper, with circles in pencil, divided into quadrants corresponding with the wires in the eye-piece. I got the position of the prominences approximately correct; but it was difficult at first to say what

colour they were. At first they seemed white; then I noticed a faint tinge of red, as of vermilion, much diluted with Chinese white. When the chromosphere appeared, it could not be said to be red. The atmospheric condition was answerable for this; and what I saw were the usual hydrogen prominences. None were in the least like the two shining white columns I saw at Ovar in 1900. All were somewhat plumy, or cloud-like, or arboreal in form. One of the latter shape had a double trunk.

Long before these five prominences in the north-east were covered by the Moon's disc, one appeared *floating* with no attachment, not more than 30°, if so much, from the north pole in the north-west quadrant. Others gradually revealed themselves till I had mapped seven; in both quadrants twelve. I saw none in the southern hemisphere. All were pale, but very brilliant. Those in the north-west quadrant had, perhaps, a trifle more colour.

I found it useless to observe the corona with the telescope, so I had several good looks with the naked eye. Though there was a small, thin cloud covering the Sun, the corona was most brilliantly visible through it. It was not pearly or silvery white, nor was there any trace of colour. The Moon was the blackest of blacks, and the corona the intensest of whites, and very bright. The full Moon at the meridian was not comparable with it in tint or brilliancy. I thought of our Lord's garments at the Transfiguration, "candida nimis velut nix."

The diameter seemed about half a solar diameter broad. It was, of course, impossible to see any faint outlying parts. It appeared pretty equal in breadth all round, the edge bordered with aigrettes. For the last ten seconds it was free from clouds; but I saw nothing to add to, or take from, what I have recorded.

I had to give the order to close cameras, so I watched carefully for the orange-red glow of the chromosphere. I saw no decided colour, but the western limb suddenly became so bright that in some alarm I called out "Close"; and in one second the sunlight appeared. Totality had lasted 3 minutes 25 seconds, as against 3 minutes 36 seconds calculated.

The sunlight gained with extraordinary rapidity, by bounds as it were, so that almost at once all impression of eclipse was gone. Before long, one felt the Sun beginning to scorch again in cloudless intervals. The temperature had been agreeably cool for some time before totality. The darkness

may be estimated by the following:—The grey notepaper on which I drew had a fairly dark circle in pencil, and cross-lines about twice as broad and dark. The latter were clearly visible, but the former so little so that I found my red chalk-marks were some within and some without the circle.

I heard from others that they had seen the undulating shadows. None of us had time to look for them.

6. DESCRIPTION OF THE PHOTOGRAPHS, BY MR. W. H. WESLEY.

Mr. W. H. Wesley, the Assistant-Secretary of the Royal Astronomical Society, whose expert knowledge of photographs of the solar corona is unrivalled, has very kindly examined the original negatives, repeating in the present instance the courteous office which he performed in the case of Professor Joly's negatives taken with the same instruments in 1900, and has sent the following Report, for which we are greatly indebted to him:—

DESCRIPTION OF THE INDIVIDUAL NEGATIVES.*

I. *Exposure*, 4 *seconds* (Plate I., fig. 1).—The plate is somewhat fogged, and there is a trace of double exposure; but the lower details are very well shown, especially in the north-east. The greatest extension is about 12 minutes of arc.

II. *Exposure*, 8 *seconds* (Plate II., fig. 2).—The plate is very much fogged, and is strongly marked with streaks, probably caused by the grain of the wood of the box or plate-holder. The most conspicuous of these streaks is outside the corona, which is not greatly injured by them, except in the north-west, where the greatest extension has apparently been cut off at a height of about 18 minutes of arc from the limb. There is considerable detail in the outer part of the corona.

III. *Exposure*, 15 *seconds*.—The plate is fogged and streaked, but not so much so as Plate II. The extension is less; but the negative is denser than the latter, and the details are clearer, especially on the east.

IV. *Exposure*, 50 *seconds* (Plate II., fig. 1).—The plate is fogged and

* Prints from negatives I. and II. are reproduced as Plate I., figs. 1, 2; and from negatives IV., V., as Plate II., figs. 1, 2.

badly streaked; the streaks much interfering with the details of the corona to the north and south. The negative is less dense than negative III., and the details not quite so clear. A curious comet-like streak, on the east side, beginning about 10′ from the limb, is evidently a photographic defect, as it is not shown on any other plate.

V. *Exposure*, 15 *seconds* (Plate II., fig. 2).—The plate is a little fogged, but there are no streaks; the negative is dense, and the detail very well shown, especially about the great prominence and on the west limb. Greatest extension, about 18′.

VI. *Exposure*, 6 *seconds*.—The plate is fogged, and there is a slight trace of double exposure; but the negative is dense, and the low details are extremely well shown, especially on the east. Greatest extension, about 12′.

The Moon's image on the plates has a diameter of about $2\frac{1}{8}$ inches.

The Prominences.

By far the most conspicuous feature is an enormous bank of prominences on the east limb, nearly 2 minutes of arc in height, extending from the equator to more than 30° north. It consists of six or more tree-like forms, separate at their bases, and united at their summits, where they are nearly continuous. They are very dense, except at the equatorial extremity of the group, where they become thin, thread-like, and apparently detached from the limb. The group is very well shown on negatives I. and II., but almost covered by the advancing Moon on V. and VI.

Between this great mass and the north pole are two small prominences; and south of the equator, on the east limb, are several other small ones. A little to the west of the north pole is a fine hooked prominence (well shown on negatives V. and VI.); there are five other prominences, north of the equator, on the same limb. Above one of these* (a little north of the equator) is an interesting arch of flocculent structure, which may be small detached portions of prominence matter.

* This is the metallic prominence observed by Professor Fowler, between 10.35 and 11.5 on the morning of the eclipse in the spectroscope at Castellón de la Plana, and of which he writes (Proceedings R. S., vol. lxxvii., "Reports on the Total Solar Eclipse," p. 23):—"In the spectrum of this prominence the b and D lines were exceptionally bright, as were also a great number of other lines ordinarily seen in such eruptions." (Note added by A. L. C.)

The Corona.

The principal characteristic of the corona of 1905 is its complete agreement with the type associated with periods of sun-spot maxima, as shown in 1882 and 1893. This type may be briefly described as that of a corona extending to a more or less equal distance all round the Sun, without polar rifts or equatorial extensions.

Owing to its general uniformity and want of well-marked divisions, it is difficult to give an intelligible description of the corona of 1905. It possesses no well-defined separate groups of rays; no very conspicuous gaps or rifts; no very marked synclinal structure; and no clear instances of the curves of double curvature so commonly seen in other years.

About 20° south of the equator, on the east limb, is a large rift, much filled up, but presenting most of the special features of the polar rifts seen at minimum periods. In the centre of this rift are straight, nearly radial rays, and on either side the rays curve away from the centre, becoming more and more inclined from the radial, the edges of the rift being almost tangential. The resemblance to a polar rift is increased by the presence of certain narrow spaces, so conspicuously bright (in the negative) that one is inclined to regard them as *dark* markings, such as have been suspected among the polar rays in other years. The presence in equatorial regions of rifts of "polar" character seems a special feature of the maximum corona, as it was noticed also in 1882 and 1893.

The northern edge of this equatorial rift is the boundary of a mass formed of nearly parallel rays running north-east from that part of the limb which is occupied by the great north-east mass of prominences. The coronal structure above the latter is of the greatest complexity, consisting of curving, interlacing, and overlapping arches, rising to a height of 4′ or 5′ from the limb. In no other part of the corona is the structure more complicated, and nowhere is the overlapping of superposed structure more evident. The whole north polar region is filled by large conical masses with but little structure, and that mostly consisting of parallel rays. The coronal rays curve over the hooked prominence near the north pole in a very characteristic manner.

To the west of this is a narrow rift, reaching to the limb, and forming the northern boundary of the western equatorial mass, which shows not the slightest indication of the "polar" rift seen on the east limb. The western mass consists mainly of somewhat parallel rays, except in a small region above a prominence a little north of the equator, where its structure appears flocculent, with very small detached spots, perhaps detached portions of prominence matter. Near the south pole is a fairly conspicuous rift, without any of the character of a polar rift, and in the south-west is a wider rift, much filled up. The corona has the least extension in the south and south-west; and, generally speaking, its structure is less complex and interesting than in other regions.

We supplement this interesting and valuable Report of Mr. Wesley, on the general character of the coronal and prominence structure, by a more detailed study of the various phenomena, with approximate measurements of position-angles from the photographs.

7. THE PROMINENCES AND ASSOCIATED PHENOMENA.

The following is the list of prominences whose positions have been determined from the photographs; the position-angles being reckoned from the apparent north through east, south, west:—

No.	Position Angle.	No.	Position Angle.	No.	Position Angle.	No.	Position Angle.
1	+ 4°	10	+ 84°	18	+ 122°	26	+ 299°
2	+ 45°	11	+ 89°	19	+ 127°	27	+ 301°
3	+ 51°	12	+ 95°	20	+ 131°	28	+ 302°
4	+ 59°	13	+ 102°	21	+ 158°	29	+ 311°
5	+ 63°	14	+ 105°	22	+ 173°	30	+ 314°
6	+ 67°	15	+ 112°	23	+ 178°	31	+ 322°
7	+ 72°	16	+ 115°	24	+ 185°	32	+ 325°
8	+ 74°	17	+ 117°	25	+ 260°	33	+ 340°
9	+ 78°						

The list is a very full one, but most of the prominences were of small dimensions, excepting the group on the eastern limb from + 74° – 105°, the

mean height of which was about 1′, and the highest one at position-angle + 84° reaching the height 1·3′. Mr. Fowler observed the prominences at his eclipse-station, Castellón de la Plana, at 10.35 to 11.5 the same morning, and has kindly sent his list for comparison. It contains 26 prominences; but while prominences 2 to 6, which are conspicuous on negative I., are wanting from his list, there are four in the south-west quadrant that are not found in our photographs, one of them being fairly bright. This is probably accounted for by the fact that the lunar diameter exceeded the solar diameter on the eclipse day by 1′ 3·6″, and that the direction of the path of the centre of the Moon at Vinaroz was from P. A. 295° to P. A. 115°, second contact taking place at P. A. 92°, and third at P.A. 318°, thus covering these prominences of small height. There is, therefore, no evidence on our photographs of the existence of so-called anti-podal groups of prominences, as has been asserted in more than one published account of the eclipse. The great eastern group was an exceedingly fine one, and was composed of six tree-like prominences, with a detached cloud-form at its extremity. It commences at P. A. + 74° as a gradually rising bank, culminating at + 84° in a fine prominence which is still visible in the last negative, VI., of our series. The whole seven are seen in negative IV., but this one only in negative V. The lower corona in the neighbourhood of these groups of prominences is very much disturbed. A series of interlacing rings or arches surmounts the group, their mean height from the edge of the Moon being very nearly 3′. The general appearance is that of rings seen more or less edgewise, intersected by dark spaces. There are four such distinct bright edges, almost bright rays, from P. A. + 75° to P. A. + 85° over the three first prominences of the group. Is it possible that such arches or rings seen edgewise would give the appearance of the white prominences seen by Tacchini in the eclipses of 1883 and 1886? The heights of these bright edges in the present instance would be about 81,000 miles. At position-angle 105° is an oval, dark ring at a height of 170″ from the Moon's limb, and with axes 140″ and 70″, which may be possibly dark matter, but also may be merely contrast amid the swirls of the disturbed coronal regions. In negative VI. is a vortex ring, with a white central dot, which extends from P. A. 72·5° to P. A. 86·0°, that is, over the more northerly portion of the great prominence group which has now almost disappeared,

the position of the white centre being at 78·5°. The height of the ring is about 200″. A very similar structure is to be found in Professor Dyson's ten-seconds photograph of the eclipse of 1901 (May 18), which also is in the immediate neighbourhood of a fine prominence. Similar appearances in connexion with prominences were described in visual spectroscopic observations taken in 1870 by Sir Norman Lockyer. The phenomena in connexion with this group of prominences are completed by two fine bright streamers, seen well in negatives II. to VI., which curve towards the north. These, combined as a single streamer, formed one of the three most conspicuous in the naked-eye view of the corona. All the prominences from + 45° to + 131° are connected by a bright ring above the Moon's limb.

8. The Dark Ray and Plumes.

The next structure in order of increasing position-angle which strikes the eye in each of the photographs, except the first, is a fine set of plumes or curved rays, which, with a dark ray, form a group extending from P. A. + 125·2°, the position of the lower extremity of the dark ray, to P. A. + 156°, that of the lower extremity of the last bright plume of the group. These appearances are very striking. The dark ray can be traced to a distance of 12′ from the Moon's limb, and both its darkness and its character differentiate it from the other dark rifts in the corona, and make it probable that it is really dark matter near the Sun. As it rises, it curves somewhat towards the north, and becomes broader. In negative IV. another dark ray seems to be superposed on the bright plume at P. A. + 136°, but is not seen in any other negative.

The group of plumes consists of five well-defined members, while a sixth fainter one is shown on the negatives between Nos. 2 and 3. The following list of position-angles of their bases and upper extremities will give some idea of their curvature, which is directed mainly towards the south. The mean height is about the same as that of the dark ray, 12′, or approximately 324,000 miles.

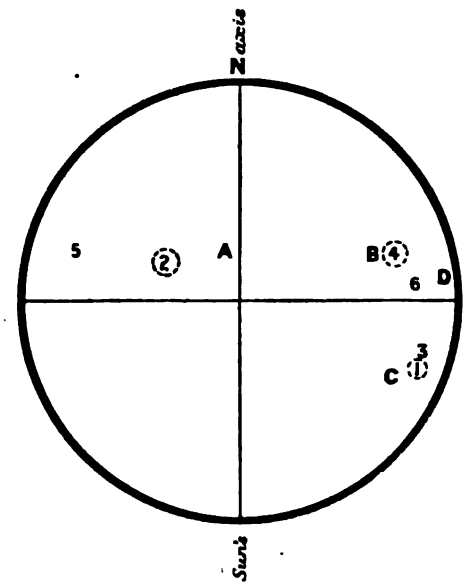
The whole group, if traced backward, would seem to converge

to a position approximately P. A. + 132°. On the day of the eclipse the P. A. of the north end of the Sun's axis was + 20·7°, which would place the

No.	P. A.		Remarks.
	Base.	Vertex.	
1	+ 132	—	Broad, fan-like plume.
2	+ 136	+ 138	A bright cone; dark ray superposed.
3	+ 142	+ 151	Crosses behind No. 2 Cone.
4	+ 147	+ 156	Very much curved Cone.
5	+ 156	+ 164	Faint.

point of convergence in latitude – 21° S.; while similarly the dark ray would seem to spring from a position near – 14° S.

Mr. Maunder, of the Greenwich Observatory, has kindly, with the permission of the Astronomer Royal, supplied me with a list of sun-spots visible from August 2nd to September 27th, and their heliographic positions on the Sun's surface. The Stonyhurst Observatory drawings have also been available for study in this connexion. The following diagram has



been drawn by Mr. William McKeon, assistant at the observatory, and on

it are plotted the mean heliographic positions, not only of the spots visible on the Sun on the day of eclipse, but also of the great spot-groups visible from the beginning of the year until October. The spots visible on the day of the eclipse are designated by the letters A, B, C, D, proceeding in the direction west to east; the centres of greater spot-disturbance during the year are marked by numbers from 1 to 6, the numbers enclosed in dotted circles signifying that these spot-centres were on the invisible hemisphere on August 30, the day of eclipse.

The following is the list of spots indicated on the diagram, with their heliographic positions, and their greatest disc-areas, from the Stonyhurst drawings expressed in terms of the 1/5000th of the visible disc :—

Spot.	Mean Heliographic		Greatest Disc-area.	
	Longitude.	Latitude.		
A	+ 115°	+ 14°	1	
B	+ 70°	+ 13°	2	
C	+ 62°	− 20°	5	
D	+ 41°	+ 7°	2	
1	+ 350°	− 16°	28	Great February spot.
2	+ 273°	+ 10°	16	Great March spot.
3	+ 50°	− 16°	9	Great July spot.
4	+ 238°	+ 13°	16	Great July spot.
5	+ 163°	+ 13°	25	Great October spot.
6	+ 58°	+ 5°	15	Great October spot,

In the first place, it will be noticed that the greater number of spot-group centres were nearer to the east than the west limb on the day of the eclipse. The longitude of the centre of the disc at 8 a.m., the time of the Stonyhurst drawing, was 113°·0, so that the longitude of the east limb at noon would be 21°·0. All the spots are tabulated and set down on the diagram relatively to the position of the Sun's east limb at noon on August 30. Spot D is removed only 20° from the limb; but its P. A. would be + 104°, placing it just at the end of the great group of prominences on the east limb. It was surrounded by very brilliant faculæ, which suggests a connecting-link between spot and prominences. The

only other spot-centre near is No. 6, belonging to the coming great October group. Spot C, the largest visible on August 30, is removed 41° from the limb; but its latitude − 20° coincides almost exactly with that of the position from which the plumes seem to radiate. It was surrounded by scattered faculæ, which preceded its arrival on the limb on August 27; its type, however, would show that it was not a new active spot. Spot 3, a July group of large area, was situated 29° from the limb near to spot C already discussed, which shows that this area had been disturbed even a month previously to the eclipse. The greatest spot seen during the last thirty years was the spot marked 1 on the diagram, the position of the place it had occupied being, on the day of the eclipse, on the invisible hemisphere, and 31° removed from the limb. Seeing that this had been the greatest spot of thirty years, and that it is a rule that a centre of such great solar disturbance is intermittently disturbed for months before and after the appearance of the great spot, it is not at all unlikely that the dark ray and plumes which radiated from position-angles very near the latitude of this spot-centre were connected with it.

9. The Bright Rays and Streamers.

On all the photographs, except No. 1, are three well-marked, bright rays at mean P. A. + 270° + 281° and + 290°, while two others less well-marked at P. A. + 245° + 256° are best seen on negative II. In appearance they are not unlike the bright plumes of the south-east quadrant, except that they are more tapering at their ends, and stretch out straight and quite radially to the solar limb. They can be traced to a like distance as the plumes, or about 12′. Extending as they do from − 21° S. latitude to + 1° N. latitude, they mark the sun-spot zone on the western side of the Sun. The corona of 1905, in its general form, is a very fine instance of that type which is associated with a year of maximum sun-spots. That 1905 was a year of maximum sun-spots is evidenced by the mean daily disc-area as derived from the Stonyhurst observations, which was 6·88, as compared with 2·54 for 1904, and 1·93 units for 1903. Its general appearance is very similar to the coronæ of 1871, 1882, 1893, and dissimilar from that of 1900, as photographed by Professor Joly with the same instruments. The mean daily disc-area for spots for 1900 was 0·55, which was very near that

of the minimum year, 1901, when the number was 0·29 units. Mr. Farran, the drawing-master at Stonyhurst, has, with great labour, made an enlarged composite drawing from all the six photographs, which has been of very great service when studied in conjunction with the photographs themselves. This drawing—and the same fact appears from negatives III., IV., and VI.—shows that the corona, independently of the long streamers, was more extended on the western than on the eastern side, and that, roughly, the wind-vane form characteristic of minimum sun-spot coronæ exists as a background on which the streamers are superposed. The general trend of the streamers is towards the north and south; the curving of some northwards being very noticeable. These streamers have filled up the open spaces at the poles, so marked in the minimum type of corona, except that conspicuous dark rifts are still apparent near either pole. It is somewhat difficult to measure the exact P. A. of the bases of the streamers on the different photographs, on account of their filmy nature; but the following table contains the mean results which are considered the more reliable :—

No.	Main streamers.	Branches.	Height in lunar diameters.	Remarks.
1	30° – 70°	30° – 39°	—	Cone-like mass.
2		39° – 68°	—	
3	72° – 88°	72° – 78°	0·6	Over the prominences : trends N.
4		78° – 88°	0·6	
5	90° – 118°	90° – 101°	0·5	Region of prominences ; trends N.
6		101° – 118°	0·6	Crosses its companion, and trends N.
7	158° – 180°	—	0·9	Ill-defined cone : slants S.
8	200° – 250°	200° – 217°	1·2	Great South wings.
9		222° – 239°	0·7	
10		230° – 250°	1·2	
11	310° – 350°	310° – 326°	—	Between two well-marked rifts at 310° and 350° : trends N.
12		331° – 338°	—	
13		338° – 350°	—	
14	350° – 30°	—	—	—

The longest and most striking of these streamers is the great south group, marking the south polar regions, which consist of two long wings extending to the edge of the plate in negative IV., that exposed for 50 seconds, with an intermediate branch between them. In general, the streamers appear to mark rather the regions of prominences than of spots; and their curvature is directed mainly from the spot-zones.

10. SUMMARY OF RESULTS.

1. The corona of 1905, August 30, was of the maximum type.

2. There were numerous prominences, especially one great group on the east limb of the Sun.

3. The lower corona was much disturbed over this group, with a marked structure of arches and interlacing rings.

4. A well-marked vortex-ring with a white centre was connected with the prominences.

5. A ray of presumably dark matter and a group of plumes marked the south-east quadrant.

6. The dark ray and plumes coincided in position with the sun-spot regions, and were possibly connected with the area disturbed by the great February spot.

7. Some straight, bright rays marked the south-west quadrant; also in the region of the spot-zones.

8. The general trend of the streamers was north and south, the longest streamers being placed almost at the south pole.

9. The inner corona was a ring of intense brilliancy, comparable to the full Moon.

10. The streamers seemed in general to mark the regions of prominences more than those of spots.

In conclusion, I must express my deep indebtedness to Father Sidgreaves, the Director, and to the assistants of the Stonyhurst Observatory, for much valuable help furnished in the preparation of this Report.

EXPLANATION OF PLATES.

EXPLANATION OF PLATES.

It is impossible to show on a single print all the details contained on the original negative. A deeply-printed picture will reveal the brighter phenomena, but the delicate streamers must be sacrificed; while the detail of the prominences is not seen on a print which gives the fullest extension of the streamers. The four pictures reproduced exhibit most of the chief features of the originals.

PLATE I.

FIG. 1. *Negative* I. *Exposure*, 4 *seconds*.—The prominences are fairly well shown, especially the great group on the east limb. But the detail of the prominences has been sacrificed somewhat in the print to bring out the complicated structure of arches in the lower corona which is over them.

FIG. 2. *Negative* II. *Exposure*, 8 *seconds*.—In this print the chief features are the brilliant uniform ring of the lower corona and the streamers associated with the arches connected with the great group of prominences.

PLATE II.

FIG. 1. *Negative* IV. *Exposure*, 50 *seconds*.—The picture has been deeply printed to illustrate the structure of the plumes on the east limb below the prominence group, which is also very well shown. The extension of the streamers is greatest on this plate; and on the original the south wings extend right to the limit of the plate.

FIG. 2. *Negative* IV. *Exposure*, 15 *seconds*.—The Moon has now nearly covered the east limb group of prominences; but the structure of the streamers, with their dark rifts, as also the plumes and dark ray on the east, and the bright radial rays on the south-west, are special features of this plate. It can be compared with the plate exposed for the same length of time in 1900 to illustrate the difference between a maximum and minimum corona.

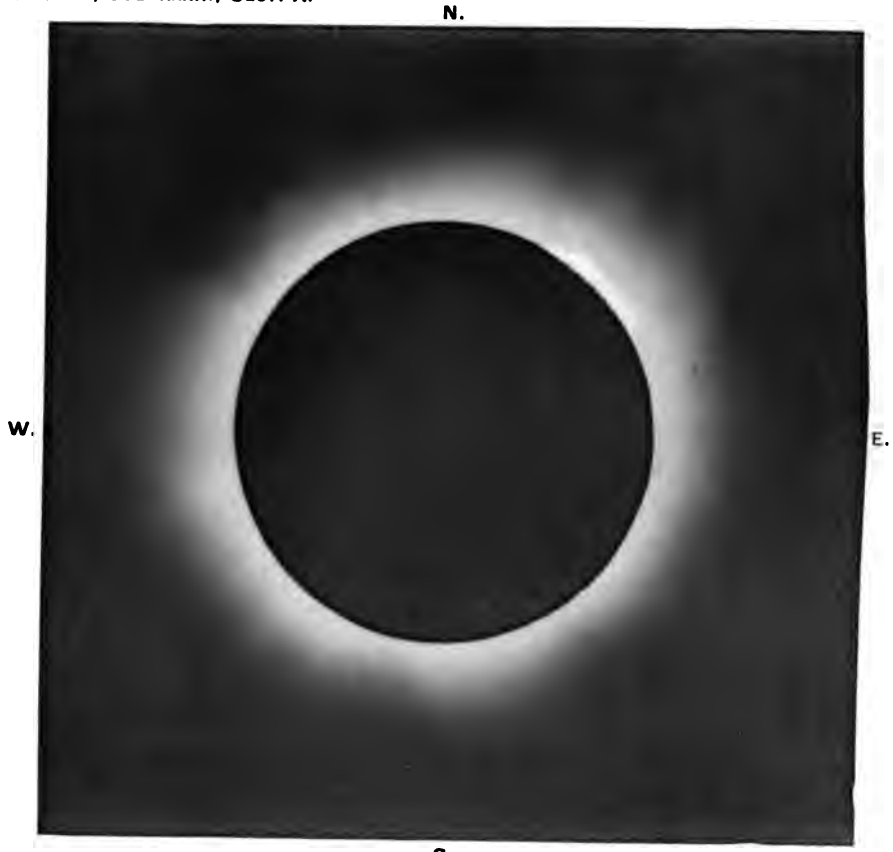


FIG. 1.—EXPOSURE 4 SECONDS.

Benrose Ltd., Colls., Derby.

FIG. 2. -EXPOSURE 8 SECONDS.

THE SOLAR CORONA, AUGUST, 1905.

N.

W. E.

FIG. 1.—EXPOSURE 50 SECONDS.

W. E.

S.

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FIG. 2.—EXPOSURE 15 SECONDS.

THE SOLAR CORONA, AUGUST, 1905.

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VOLUME XXXIII., SECTION B, PART I

R. F. SCHARFF, R. J. USSHER, GRENVILLE A. J. COLE,
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THE EXPLORATION OF THE CAVES OF COUNTY CLARE

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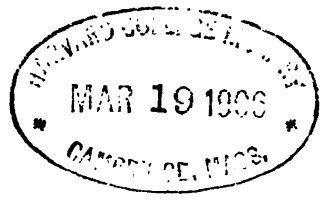

TRANSACTIONS

OF THE

ROYAL IRISH ACADEMY.

I.

THE EXPLORATION OF THE CAVES OF COUNTY CLARE.

BEING THE SECOND REPORT FROM THE COMMITTEE APPOINTED TO EXPLORE IRISH CAVES.

(PLATES I.–V.)

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1. INTRODUCTION.

By R. F. SCHARFF, PH. D., B. SC.

OUR first report dealt with the results obtained by the Committee's operations in the County Sligo.* When we became aware of the success which had attended our cave-explorations in that part of Ireland, we all felt anxious to know a little more of the cave-fauna of south-western Ireland, where so many zoological and botanical relics of the past have persisted to the present day. We therefore made inquiries as to a suitable field for further researches in the south-west, when our attention was directed to a series of caves in the County Clare.

* "The Exploration of the Caves of Kesh, Co. Sligo."—Trans. R. I. Acad., vol. xxxii. (sect. B), 1903.

In the narrative of the investigations which we have undertaken, Mr. Ussher deals so exhaustively with the general features and position of the caves that there is no need to repeat his graphic descriptions here. It was a most fortunate circumstance that the member of our Committee who had so successfully carried out the previous field-operations, often under great hardship, in the County Sligo, should have expressed his willingness to continue to direct and superintend similar work in future. Without Mr. Ussher's enthusiasm and devotion to scientific work, further cave-research would probably have had to be suspended for some time. Not only the Cave Committee, but all those who have watched the investigations which are historically and faunistically so important, are greatly indebted to Mr. Ussher for offering his valuable services, which were gladly accepted, for the continuance of this work.

Month after month, Mr. Ussher and his staff toiled in the caves. When he commenced the operations, two skilled attendants—James Duffy and Robert Griffin—were sent from our National Museum, to assist him. Later on he had to rely on one of his own men, John Power, for help.

The procedure adopted in the work was, to carefully remove the surface layer of the cave-earth, after having taken accurate measurements, as far as possible, of the size and extent of the subterranean passages. The objects and implements found in every two feet of earth, from the mouth of the cave inward, were then collected and transferred into a parcel or bag, which received a number.

Thus when, in the body of this Report, in connexion with the bones or other objects found, a number is mentioned, the latter refers to a particular bag. After the two feet of earth or clay had been searched through at the cave entrance, it was thrown out, and another two feet of earth was similarly inspected. After the surface-layer had been removed, the lower stratum was similarly dealt with. The bags were then forwarded to the National Museum, together with the notes on the more important objects found.

In order to recognise and describe the numerous specimens discovered, they required a thorough cleaning. Every object had then to

be numbered, so that it might afterwards be possible to determine the exact position which it originally occupied in the cave, both vertically and horizontally. Worked out in this systematic manner, the objects and bones found in the caves should give us a kind of history of the events which happened in the district surrounding the caves from the present day to the dim ages of the past, long before Man learned to write a history of the country, or perhaps even before Man's appearance in Ireland. Unfortunately, the Committee were unable to secure the sympathies of the Badger in preserving an unbroken record of these events. Badgers have apparently inhabited the caves, periodically, for a very long time past; and, during their stay, they have utilized their powers of excavating, in tunnelling the deposits in various directions, and in disarranging their natural sequence considerably. Though, as a general rule, the objects which were originally in the upper layer were still found there, many of them, no doubt, had slipped down into the lower stratum, while even the converse must have occasionally taken place.

Altogether, Mr. Ussher sent about 50,000 bones from the Edenvale Caves, and about 20,000 more from the Newhall and Barntick Caves, to the Museum. Besides these, there were a number of geological specimens on which Professor Cole has given us a valuable report, and also the objects illustrating the human occupation of the caves, which have been described by Mr. T. J. Westropp.

I wrote a complete catalogue of all the specimens found, and then picked out from among the bones those belonging to Man and Birds. The former were submitted to Professor A. F. Dixon, who has endeavoured to trace from them the nature of the human inhabitants of the caves; while Mr. E. T. Newton, to whom the Committee is under a great debt of obligation, very kindly furnished us with a detailed report of the Birds which he had identified from the bones sent to him. Finally, Mr. Ussher's assistance was once more asked for, and readily given, in supplying us with a report embodying his view on the past and present distribution of the Birds referred to by Mr. Newton.

The Committee was primarily indebted to the British Association

for the necessary funds in carrying out these cave-explorations; but the Royal Irish Academy, through its Fauna and Flora Committee, has also borne a considerable share of the expenses, for which we beg to tender our thanks. The Department of Agriculture and Technical Instruction, in granting permission to Professor Cole to visit the caves, has shown its interest in these researches, and its desire to assist the Committee. But we wish especially to express our warmest thanks to Mrs. Stacpoole for her untiring hospitality, and the aid she rendered in every possible way, during our prolonged sojourn on her property; to Mr. Richard Stacpoole for his kind permission to work the caves; to the Misses Stacpoole, Miss Neville, and Miss Parkinson for much assistance in searching for relics, whereby many objects, difficult to detect, were discovered. We also tender our acknowledgments to Mr. and Mrs. MacDonnell, for their kind aid and facilities afforded us to explore the Newhall caves. We thank all who worked for us, for their constant and careful assistance.

2. NARRATIVE OF THE INVESTIGATION.

By R. J. Ussher.

Edenvale—Alice and Gwendoline Caves. (Plate I., figs. 1, A; 2.)

During the inquiries about Irish caves, our attention was directed by Mr. Hugh Massy Westropp to two adjoining galleries, just above the 100-foot contour line, in the escarpment of the limestone ridge on which Edenvale House stands. I visited these caves with Dr. Scharff in April, 1902, and from the earthy strata which they contained they seemed promising. The following June we cleared out the principal or right-hand cave, which proved to be an irregular tunnel that ran for 80 feet under the limestone plateau, and then ended in an upward orifice. We called this the Alice Cave. At 15 feet from the mouth a projection in the left wall was worn smooth, as if by the rubbing of passing animals; at 38 feet, a cross-gallery led down to the left from this cave into the twin

cavity that we called the Gwendoline Cave. The next 15 feet of the Alice Cave was commodious, and its walls were much enveloped in calc-tufa.

From 55 feet onwards, the gallery became narrow, being greatly filled with stones, which seemed to have been cleared out of the wider portion of the cave. Beneath some of these stones, and just buried under the surface of the earth, where it had probably been left covered, we discovered a plain gold bracelet near the centre of the gallery. It was unconnected with any other relics, except, perhaps an amber bead which turned up about a yard further on. Near the terminal orifice the passage was choked with stones and earthy material that had fallen in through the opening, and among these was abundance of charcoal, with bones of domestic animals, a fish-bone, and a bronze wire bracelet. These objects had plainly been thrown in from some settlement above the cave, the latter having been used as an ash-pit.

In these caves there were two distinct strata: the upper one was of brown earth, with calcareous tufa here and there. Charcoal occurred in it frequently, with bones of the domestic animals so common in the ancient Irish settlements. There were also a few bones of Bear and Irish Elk in the first stratum; but the most unexpected discovery was that of the Arctic Lemming.

The second stratum was of clay, often very tenacious, of an ochre tint, sometimes purplish, and often containing black patches. The upper portion of this stratum was less tenacious, being mixed with sand in places. Some charred or gnawed human bones are referred to this upper part. The animals most frequently represented in it were Bear and Reindeer; and the Irish Elk was met with in several places.

Edenvale—The Catacombs. (Plate I., fig. 1, B.)

Having completed our work at the two first caves, we commenced on the 15th July, 1902, to open up what proved to be a cave-system of great extent that we termed the Catacombs, which was also above the 100-foot level. It was on the other side of Edenvale, in the cliff that descends

from the house towards the lake. This small sheet of water lies in the hollow of a deep cleft in the high limestone ridges; and its surface is 91 feet above sea-level. Its precipitous sides are beautifully wooded, producing a scene that strongly contrasts with the bare and craggy tracts so prevalent in County Clare.

The Entrance Gallery of the Catacombs opens towards the south-east on a road that descends from near Edenvale House towards the lake—a circumstance which rendered access easy. The mouth of the cave was, however, choked with glacial boulders embedded in light, sandy clay, and mixed with angular fragments as well as gravel-stones. Among the limestone boulders was a large one of sandstone, a material that often turned up in our excavations here afterwards, as it had been frequently intruded into the caves in the drift accumulations. We found, however, no unmixed deposits of glacial gravel, such as that encountered at the mouth of the Plunkett Cave at Kesh. The huge boulders gave us great trouble in deepening the passage sufficiently for the wheelbarrow and planks.

In working for about the first 20 feet we found, to our surprise, that this part had been already dug up; and we recognised a heap on the north side, outside the cave's mouth, as material that had probably been brought out. This agreed with the information given to me by Mr. T. J. Westropp, that the Entrance Gallery (but not the side galleries) had been dug out within the memory of his informant. Even here, however, we met with some remains of ancient animals in recesses where they had lain undisturbed.

Cross Gallery. (Plate I., fig. 3.)

The Entrance Gallery runs nearly at right angles to the cliff into the hill for 50 feet, and is crossed by a number of others which run in two directions at an acute angle to each other, producing many intersections. We selected one which was 10 feet wide, formed of two confluent caves which subsequently diverged. These were banked up with

deposits which we removed to a depth of 4 feet, following the usual method of cutting them down in benches of 2 feet from back to front.

The deep upper deposit in this Cross Gallery was undisturbed; for it lay in beds marked by seams of whitish tufa. It was tenacious near the top for about 6 inches, having probably been worked by the constant treading of animals when it was wet; below this it was of loose earth. In the third bench we met with pieces of antlers of an Irish Elk in a thick seam of tufa 18 inches below the surface. This was all apparently the first stratum; but we found both angular and glaciated limestones embedded in our next picking below the antler.

From 12 feet onwards for fully 30 feet was a layer or floor of charcoal buried at a depth of from 2 to 3 feet beneath the surface. This charcoal was in connexion with a floor of soft or caky stalagmite, and followed its curves, being sometimes interstratified between two layers of the white material.

At 18 to 20 feet a human ulna occurred at the bottom of the layer of charcoal and stalagmite; and at 24 to 26 feet, above bits of charred sticks, was a human radius. In the next bench there were quantities of charcoal which formed layers from 3 inches downwards.

At 27 feet bones of Bear were found 2 feet 6 inches below the surface against the left wall; and a Bear's radius and femur, and bones of Red Deer were embedded 3 inches below the floor of charcoal and stalagmite.

The second stratum in the Cross Gallery was of clay, tenacious in some places, sandy in others; and it contained glaciated stones and gravel-bits, as well as angular fragments. As we proceeded, we found in the clay a cake of limestone gravel with a boss of stalagmite on it, the fragment of an old floor. After 16 feet this stratum was found to be of tenacious yellow clay near the large blocks, but blackish, loose, and sandy to the left, with some glaciated stones in it.

Great Hall. (Plate I., fig. 3.)

At 42 feet the gallery lost the typical form of a river-tunnel, and became a hall whose elevated roof was left flat by the falling away of

blocks that we encountered below. At 42 to 46 feet to the left of a huge buried block we found, after removing the first digging, much admixture of tufa. In this, with bones of Ox and Pig, were a piercing instrument of bone, a flake of a white pebble, and a finely-chipped scraper of flint or white chert.

Next day we found, near the same spot, opposite the entrance to the Surprise Gallery, another flake and the tusk of a large Boar cut across and pierced to attach a string which had worn the hole; we afterwards got, just within the Surprise Gallery, a pierced sea-shell (*Littorina*). We had to blast the fallen blocks with powder; and on removing one of these, we found, at 44 to 46 feet, charcoal *in situ*.

At 50 to 54 feet is a longitudinal, water-worn ridge of limestone in the floor, like an upturned boat; and elsewhere objects of this sort showed that the galleries had once been the channels of streams, though now much above the level of the lake and valley.

From 55 to 58 feet, the hall, which had narrowed again, was bridged over, on a high level, with blocks set in thick stalagmite, which, in section, had the appearance of sugar-stick. Beneath this high-level bridge was a grey, earthy mixture containing teeth of Ox or Deer and Mouse. Beneath this was clay devoid of animal remains, of the consistency of cheese and the colour of gingerbread, with occasional black patches of manganese. The limestone fragments in it were few and angular.

Smoke Gallery. (Plate I., fig. 3.)

We named the continuation of this branch, beyond 60 feet, the Smoke Gallery, because, by means of smoke, Mr. T. J. Westropp proved a connexion between this and the mouth of the Dog's Cave.

At 3 feet 6 inches of this passage, beneath a great depth of tufa-stalagmite and limestone rubble, we found, on the stratum of clay, a shaft of a long bone of a man; and at 12 to 14 feet, an atlas vertebra was got below the surface of the clay, which, with these exceptions, was barren.

The feature of the Smoke Gallery was the elevated floor of stalagmite,

which formed a bridge or ceiling, for the foundation on which it had been formed had been removed, probably by water-action.

A limpet-shell was brought out in the barrow from beyond 8 feet in the Smoke Gallery, the other superficial remains being chiefly fox-earth bones.

Surprise Gallery. (Plate I., fig. 3.)

This branches off from the east side of the Great Hall, by a low arch, where it was choked with earth to within 6 inches of the roof; it ran for 25 feet in a direction parallel to the Entrance Gallery, and ended under the road, which stopped it up. Before that, it may have formed a second entrance to the Catacombs.

Charcoal was found here throughout the first stratum. At 6 to 8 feet, left side, a pot-shaped cavity contained an assemblage of broken human bones, and beneath them a cranium which wanted half the maxilla, and had its brain-cavity exposed by a fracture in the bone. Half the mandible was also found. The missing halves of the jaws and two leg-bones were afterwards found not far off. It seemed as if the face had been cleft asunder, and the brains exposed before the skull was buried. This discovery led us to name a new passage (which intersected the Surprise-Gallery here) the Gallery of the Unfortunate Man.

In the vicinity of the rock-cavity that contained the above human bones, two strong knife-blades were found in the first stratum.

Gallery of the Unfortunate Man. (Plate I., fig. 3.)

The first stratum here was 3 to 4 feet deep, and contained charcoal and kitchen-midden bones, with here and there a bone of Bear, Reindeer, or Irish Elk; while a metatarsal of Bear was found loose on the surface. The latter bones were probably rooted up by burrowing animals from the second stratum, in which we found a number of similar bones of those extinct animals; and the matrix which contained them was what we used to call "bone-clay," being mixed with sand or earth, and intermediate in tint between the first stratum and the lower or yellow clay.

Dog's Gallery. (Plate I., fig. 3.)

This, the most southern branch of the Catacombs, started from near the outer end of the Surprise Gallery, where it sloped down to a lower level, and, after running a course of about 70 feet, terminated in an independent opening in the cliff.

This long passage had to be emptied with buckets, as it was too narrow for the wheelbarrow. Near its intersection with the Surprise Gallery, were found several of the smaller bones of the human limbs and some charcoal, which, at 7 feet, formed a layer across the Dog's Gallery, overlaid by a layer of calc-tufa, and that again by earth. Just here, an impending shelf of rock made the cavity shallow, and beneath this shelf, where there had been a "run down" of materials, we found several bones of Bear, Irish Elk, Reindeer, and Red Deer. These were much deeper than the human bones, but were either in the bottom of the first stratum or on the top of the second.

The rest of the Dog's Gallery contained chiefly loose earth, sand, and rubble; but it yielded a phalanx of Irish Elk marked by teeth, and other bones of Reindeer, as well as of Ox and contemporary animals.

Entrance Gallery (inner part). (Plate I., fig. 3.)

The Entrance Gallery, at 25 feet, is spanned by a low arch of rock, beyond which its level falls rapidly for 25 feet more, through an extensive chamber, formed by the intersections of several cross-galleries, divided by mere points of rock.

Sand, and apparently glaciated pebbles, characterized this part of the Entrance Gallery, having plainly run in from the cave's mouth, and formed a low tract which cut across the high banks of pale, clayey deposit in the intersecting branches at each side.

At 40 to 42 feet, and 2 feet deep, were pieces of timber partly burned, and near them a perforated piece of leather and lumps of charcoal; while 2 feet 5 inches below the surface, in fine loose earth of the first stratum, was the shaft of a femur of Irish Elk, with both ends broken off.

Broadway. (Plate I., fig. 3.)

This had at its northern end two branches, whose intersection with the last gallery was 12 feet wide. The Broadway was banked up high with strata that had evidently been continuous with similar beds that remained in the mouths of the cavities on the north side of the Entrance Gallery.

In the Broadway, Badgers or Foxes had dug much in places; but from 28 to 36 feet a layer of dark material (manganese?) was traced in contact with one or more layers of tufa. The short left branch contained remains of Irish Elk; a portion of the beam of an antler was on the top of the dividing rock to the right in this branch, about 2 inches below the surface in the first stratum, which was thin, and reposed on the second stratum. There were also a few bones and teeth of Bear in the Broadway, some in the first, others in the second stratum; but it did not yield many relics until we arrived at 32 feet, where it expanded and formed a long, low junction with the Great Hall. From 28 feet inwards, the first stratum ceased, and a floor of calc-tufa rested on the clay, and contained a black layer within or under it. Thenceforward the expansion of the Broadway was filled with a mass of recent-looking stalagmite, the dip in whose layers showed that it had flowed in from the Great Hall adjoining. Even in this, there were some bones of Bear; but there was a group of large bones of Bear and Reindeer in the clay at 36 to 38 feet, where there was a deep swallow-hole, and near this orifice were two large vertebræ.

Intermediate Gallery.

Where the Broadway formed its first junction with the Great Hall, a small tunnel was discovered that ran parallel to the great Cross Gallery. This contained in brown clay, about 12 inches below the surface of the second stratum, a broken humerus of Irish Elk and bones of Reindeer; while the first or upper stratum yielded us a molar of Bear, with black material adhering to it. After this group of bones, at 4 feet, both strata became barren; until at 11 feet we met with a yellow humerus and

calcaneum of Red Deer in the clay. A blackened shaft of crystalline stalactite lay in the first stratum.

Northern Section.

The continuation of the great Cross Gallery showed the same high-lying beds of deposit that had been cut across in the Entrance Gallery.

This north extension of the Cross Gallery was only followed for 20 feet. It was very wet, having the most copious drip in the cave, and the strata had suffered much disturbance from water-action. Nevertheless charcoal and bones of modern animals as well as of Bear and Reindeer were found here; in a recess to the right, deep below the surface, were two portions of a bronze article; the larger portion resembled a strap with buckle attached, and it was ornamented with a design in silver plating. Within the arch, which contracts the Entrance Gallery at 21 to 25 feet, was an extension of the east branch of the Broadway which we called the Tapering Gallery. The first stratum, a fine dry earth, which was shallow, contained a very fresh-looking jaw of Arctic Lemming; in the second were remains of Bear.

Westropp Gallery. (Plate I., fig. 3.)

The other branches to the right contained little of interest until we reached the end of the Entrance Gallery; but at that point a wide and lengthy cave branched off to the right, running parallel to the Broadway and almost in continuation of it. To this we gave the name of the Westropp Gallery; and we excavated it for seven days—a very laborious work, owing to the deep and compact bed of yellow clay that it contained, and to the amount of wet which trickled almost in a stream from within. In this broad gallery, the convex surface of the deposits approached the flattened roof, and a path worn by animals ran along the centre.

The strata dipped much on the west side, where the depression in the second stratum was occupied by the material of the first stratum mingled with tufa. In this were found several relics of the Irish Elk; and coupled with the discovery of other remains of this giant deer in the upper stratum

of the Broadway, and with the fact that the four marrow-bones we found were broken, it seems possible that these bones may have been brought in by early Man, as in the Ballynamintra cave.*

Near the commencement of the Westropp Gallery, another strip of thin leather occurred, which was perforated with a knife-cut. Sometimes in the first, but more often in the second, stratum, we met with bosses of crystalline stalagmite which indicated the break-up of an old stalagmite floor of no great thickness.

The second stratum in a few places consisted of fine sand, like Portland cement; but it was usually of a very tenacious clay, chiefly ochre or yellowish-brown, but often pink or terra-cotta, with a material like Indian meal and patches of manganese. It contained scarcely any animal remains when it had that aspect. After we had worked the Westropp Gallery for about 30 feet we had to abandon it, owing to the amount of wet, aggravated by a rainy season; and we were discouraged by the unproductive character of the clay. There was, however, no evidence that this part of the cave was near its termination.

Newhall—Bats' Cave. (Plate I., fig. 1, c; and Plate II., fig. 1.)

The public path that leads from Ennis to Killone Abbey and the Holy Well is known as the "Pilgrims' Road." It passes through a picturesque part of the Newhall estate, between the demesne and Ballybeg Lake. This "Well Park," as it is called, is diversified by limestone heights, crag, trees, and rich pasture. On its west side the pathway is overlooked by a steep ridge of rocks which, a little above the 100-foot contour-line, is pierced by two caves that we dug out in June, July, and August, 1904. These face a little to the south of east; and it is remarkable that their elevation above sea-level corresponds with that of the Edenvale caves we have been treating of, which are three-quarters of a mile distant, and separated from the Well Park by a lofty ridge.

The Bats' Cave was so called because, on our first visit in 1902, Dr. Scharff found in it six specimens of the Lesser Horse-shoe Bat, a

* "Explorations in the Bone Cave of Ballynamintra, near Cappagh, Co. Waterford." Trans. Roy. Dub. Soc. (N.S.), vol. i., 1881.

species common in the caves of this district, in which its bones were found.

This cave had an expanded mouth, the roof of which had evidently extended much further out than it now does, as shown by the huge fallen masses of limestone that encumbered the entrance. Some of these must have fallen into the positions in which they were found before the bones and relics that turned up were lodged between them.

We found on the surface a blackish earth, which lay upon a paler, redder earth; and this sequence occurred in a variety of positions.

In the centre, at the cave's mouth or outside it, we turned up a bed of charcoal, and uncovered a hard-trodden floor, partly compacted of pounded or trodden spar, a material of which the huge blocks were largely composed. The ordinary kitchen-midden bones were plentiful; and we found some human foot-bones, remains of Red Deer, and two metatarsals of Bear somewhat decomposed, as well as an ungual phalanx of Bear, within the cave's mouth; also shells of limpets and a marine mussel. A bronze pin of an early type was found, and several objects of bone; two of these had long slender worked points; and there were two Dog's or Wolf's canine teeth which had been adapted for implements, one with a groove cut round its end, and the other pierced. Fragments of hand-made pottery with quartz grains also occurred in the mouth of the Bats' Cave, and one of the round stones, like a pheasant's egg, that the ancient Irish used to collect. There were also two segments of those Carboniferous fossils which were sometimes used as "cursing-stones."

The second stratum in the cave's mouth was of a loose, reddish-chocolate earth, and contained numerous fragments of spar. Bones were scarce in it; but we came on a tibia of Bear which made us dig deeper, when we met with worn pebbles, and, below this, fine sand in places. As we proceeded to dig the second stratum, we met with sand, gravel, pebbles, and small boulders, chiefly of limestone, but some of purplish-red sandstone. This did not appear to be a true Glacial gravel, as sand occurred here and there, as though it had been sorted by water.

At the point where the cave's roof commenced, we found, in the second stratum, an ulna of Irish Elk; and at 5 to 7 feet, near a swallow-hole to

the left (which was partly blocked with glaciated stones), were dug up the pelvic bones of both sides of the same species.

From 7 feet onwards, the second stratum rose to a higher level; and its staple was Glacial gravel and small glaciated boulders. At about 15 feet, the cave narrowed; up to this point the wider part of it had been so encumbered with huge blocks that we could not divide it into 2-foot benches. A vertebra of Ox and a half maxilla of a Deer, in the first stratum, had lumps of charcoal stuck into their crevices; and the Arctic Lemming was represented here.

From 15 feet onwards, there was a deep layer of tufa at the base of the first stratum; about 18 feet, the discovery of a Bear's rib, deep in the second stratum, served to show that its glaciated materials had been *remanié*, and that this deposit was post-Glacial.

At 20 feet, 18 inches deep in the tufa, and nearly 3 feet deep in the first stratum, were part of a tibia of Bear, and a phalanx of Deer. In this tufa, the absence of worn or glaciated stones, and the presence of angular fragments, were marked features; its lower portion reposed on a cake of solid stratified stalagmite.

At about 25 feet from the entrance, and 2 feet deep, in the brown earth of the first stratum, was found a round stone bowl, whose blackened interior showed that it had served as a lamp; a bit of tufa-cake was sticking to its bottom when it was brought by John Power, who found it.

On digging deep, from 22 to 26 feet, in a stiff, dark brown earth, were bones of Ox, Pig, Goat, Irish Elk, Reindeer, and Red Deer, this mixture being probably due to the vicinity of a swallow-hole; lower still was coarse, stiffly-packed gravel, and beneath that pure sand.

At 26 feet, the lower part of the cave terminated in a central swallow-hole, beyond which a rocky barrier interrupted the second stratum; but beyond that, at 27 to 29 feet, the cave deepened again, and the second stratum, which re-appeared, contained a phalanx of Reindeer.

At 34 to 38 feet, a great fallen block was wedged between the narrow walls of the cave, which turned to the left with a tortuous course; above the block was brown earth of the first stratum, and beneath it Glacial

gravel; but in this were fragments of a long bone of a large mammal, blackened and encrusted with sand.

From 44 feet onwards, most of the first stratum was sand, except from 62 to 68 feet, where the normal brown earth reappeared. The former material was like sea-sand, but darker, showing much of the tint of purplish sandstone; in it were angular fragments, but seldom pebbles; and its contained bones were of the usual type of the first stratum; at 50 to 52 feet, a rubbed-down tyne of Deer's antler was found in it.

At 60 to 62 feet, along the upper horizon of the deposits, a bench of brown clay adhered to the right wall; but it was replaced by sand at a lower level; in this clay were crumbs of tufa and fragmentary bones of Frogs and other small animals, as well as broken land-shells.

At 44 to 46 feet, the first stratum reposed, without tufa between, directly on the second-stratum gravel, which was hard and close, and was composed of glaciated pebbles in a sand which made a hissing sound as it was poured out. It contained almost no fossils; but, on digging deep at 49 feet, we found a Bear's humerus, of a deep orange colour. Again, at 50 to 52 feet, we found what seemed Glacial gravel, deep down.

At 57 feet, and between 66 and 70 feet, were swallow-holes on the left, which contained some remains of Bear and Reindeer in sand.

Newhall—Elder-Bush Cave. (Plate I., fig. 1, D.)

More than 400 feet south of the Bats' Cave, in the same escarpment, the entrance of the Elder-Bush Cave looks directly down upon the path that leads to the Holy Well, with the tract of wooded crag beyond it; then Ballybeg Lake, which opened up a distant view to the left of Clare Abbey, and mountains in the north-east of the county.

The cliff-face at this cave consists of well-defined strata separating in benches and cuboidal blocks with some open fissures along the joints of the limestone. Following the planes of these joints, the main or Elk Gallery, which is at right angles to the cliff, is intersected in three places by cross-passages which form six branches: first, across the porch at the mouth; secondly, at 22 to 24 feet; and, thirdly, at 45 feet, where

the Elk Gallery ended. The porch was formed by a portion of the first intersecting gallery, the side of which furthest from the hill had fallen away; but much of the foundations of the fallen wall remained in the form of a reef of rock that we had to blast so as to approach the bottom of the Elk Gallery on a level, and remove its contents.

The upper stratum, outside the entrance, was dark red-brown earth, passing downwards into reddish earth. In the porch, at the entrance of the right-hand gallery, was a dense, well-defined bed of charcoal, which reposed against pale, ferruginous earth that lay against the rock-buttress of the right wall. Beneath this earth was lead-coloured limestone gravel. In superficial earth, between stones outside the entrance, on the right, was found a long, slender bone pin, and charcoal close to it.

The staple of the second stratum was limestone gravel, with occasional bits of purple sandstone. Boulders of various sizes, worn stones, and pebbles were found throughout the deposits, but increased the deeper we dug, though there was no unmixed bed of Glacial gravel, as in the Plunkett Cave at Kesh. As we got to the entrance of the porch, the gravel was piled against and over buff-coloured sand in talus form.

The main cave was called the Elk Gallery, from a phalanx of Irish Elk found at the bottom of the first stratum; this was loose, brown earth of a depth of 5 feet, the gallery being high and narrow. At 8 feet there was a seam of charcoal 2 feet below the surface. At 18 to 20 feet, and in some of the side galleries, the earth had been much disturbed by the digging of Badgers.

A leading feature in the first stratum of the Elder-Bush Cave, was the frequency of objects left by man and of human bones, especially those of the hands, arms, and feet. These were usually associated with the bones of domestic animals, and with charcoal which, in several cases, adhered to them; and several marine mussels and limpets were found in the same connexion, as well as sharpening-stones.

At 30 to 32 feet in the Elk Gallery there was a perforated marine univalve shell. Carboniferous fossils also occurred loose in the first stratum, having possibly been brought in by the human inhabitants.

We found human bones in both branches of the gallery that intersected

the porch, in the Elk Gallery especially at its second intersection, which was called the Cross Roads, and in both the branch galleries that diverged here: in that to the left was a bit of thin leather, a sod of peat, and a small iron nail; while, in the right-hand gallery, a human scapula was at the base of the first stratum with gravel of the second stratum adhering. Beyond the Cross Roads, human hand- and foot-bones continued to occur; and at 34 to 36 feet, we found, in the first stratum, a neatly-carved little implement of bone, having a fine point at one end, and a chisel-edge at the other, the shoulders of the chisel being neatly cut and almost symmetrical; also another piece of thin leather, such as is used for sandals by the Aran islanders.

At 45 feet, another pair of galleries branched off, which contained very few human bones; but in that to the left we found, in the first stratum, the upper half of a large Bear's canine tooth, the lower half of which had been cut off irregularly. In no case did we find anything approaching to a human skeleton; but the bones of man were scattered through the beds of earth. We found nothing to show that a burial had taken place. At 16 to 18 feet, on the right of the Elk Gallery, a small, low cavity occurred, which must have been used as a receptacle for bones, as its first stratum, for 4 feet, contained quite a pile of those of domestic animals, with charcoal, and a burned bone; also a human ulna and vertebra.

Without detailing the several branches of this cave, which would involve repetition, we may say that the upper stratum of earth, which contained the human relics, was in the inner passages much rooted by Badgers, whose bones, bedding, and dung occurred there in large quantities.

Bones of Bear were obtained in this, as well as in the second stratum, whether *in situ* or turned up by Badgers it is hard to say. In the left gallery, off the Cross Roads, was a jaw of a cat, which has been referred, by Dr. Scharff, to the African Wild Cat. In one case, a trap was met with holding a Badger's toe, and the remains of the animal, with hair still on them, lay near by.

From 24 to 45 feet the Elk Gallery became very low, and was filled up to within 6 inches of the apex; yet at 40 to 42 feet we found, in the

second stratum, an iron clasp-knife or large pen-knife. No human being could have reached the spot as long as the gallery was choked. If this knife were forgotten in the cave with a smell of flesh on it, possibly a rat may have dragged it in as it would drag a bone.

At the base of the upper stratum here was a bed of hard stalagmite, not crystalline, but in layers.

In this, as in the Bats' Cave, the lower stratum was mainly composed of what seemed to me Glacial limestone gravel, which increased the deeper we dug, and became unfossiliferous. The tenacious yellow clay, so abundant in the lower levels of the Catacombs, was absent; but a pinky-brown clay was met with in the innermost gallery to the right, a branch which we abandoned, as it was unproductive.

In the Elder-Bush Cave, the evidences of human occupation, and the association of man's work with the canine tooth of Bear, were the leading features of interest.

Barntick or Cragmore Cave. (Plate I., fig. 1, E.)

This small cave is on the east side of Ballybeg Lake, in the townland of Barntick, and penetrates a mass of limestone below the 100-foot contour line. From it, the Elder-Bush Cave confronts one from the other side of the lake. Outside the entrance, in loose, dark earth, among angular blocks of limestone and bones of domestic animals, we found a broken human mandible and fragments of the cranium. We also met with a cuboidal object of Deer's horn, ornamented with the incised pattern of dots and circles so commonly used by the ancient Irish.

Deep in the upper stratum, or on the top of the reddish earth beneath it, we found a small iron stiletto, with traces of the wooden handle adhering to it.

The first stratum was of a dry, blackish, crumbly earth, paler beneath, and contained many bones of small mammals and birds.

The single gallery, which was low, curved to the left, and then, after 20 feet, turned to the right at an acute angle. In this first reach we found a neatly-shaped hone of chert.

At 40 feet along the crooked passage, the cave expands into a boat-shaped chamber. Here the superficial stratum was like peat; and a piece of undoubted peat was found and preserved.

The second stratum in the chamber was first dun-coloured, and then of a warm brown like the Edenvale clay. In it were few bones.

The exploration of all the caves referred to extended over the summers of 1902–1904, and comprised 32 weeks' work.

3. GEOLOGY.

By Grenville A. J. Cole, F.G.S.

The caves of Edenvale and Newhall have been characteristically excavated by running water in the face of small cliffs of Carboniferous Limestone, and along the planes of jointing and stratification that stretch parallel to the face or inwards. They thus assume in plan the typical rectilinear arrangement, frequently with right angles between their several branchings. The individual caves are small, and were deserted by the subterranean waters before any large halls had been opened out along their courses. The tendency for adjacent passages to become united by solution of their walls is well seen in the Catacombs, where sharply-edged partitions, like narrow inverted boats, stand up here and there, as relics of former barriers. (Plate I., fig. 3.) The subsequent deposits of calcium carbonate have formed stalactitic and stalagmitic crusts, which are best seen on the clean white walls of the Alice and Gwendoline caves at Edenvale.

The rectilinear features of the walls and entrances are beautifully shown at the Elder-Bush Cave in the Newhall series, where a veritable porch and a small hall with side galleries occur. (Plate III., fig. 1). The entry to the Dog's Gallery at the Catacomb cliff-face is also cleanly opened along the joints, resembling an Egyptian doorway. The dip here is slightly inward, under Edenvale House. The narrow and inconvenient Bats' Cave

at Newhall has been excavated along an inclined joint-fissure, the walls converging above, while no conspicuous rectangular joints occur at this point. This cave, close to the Elder-Bush Cave, presents, therefore, a striking contrast to it and to the others in the district, and must have afforded a poor dwelling-place, compared with which the Alice and Gwendoline caves must have appeared palatial.

There is no very clear evidence as to the relations of the caves to the Glacial phenomena of the district. The Glacial deposits of the surface have been largely removed by denudation; and the limestone comes out in bare terraces and little scarps when free from plantations and underwood. As at Keshcorran, in the County of Sligo, the scarps have doubtless been worn back, and the terrace-structure has been redeveloped, during post-Glacial times; but the caves may have been previously open on the older cliff-fronts, and have admitted a certain amount of gravel as the ice melted and shrank away. The pebbles of limestone and grit found in the Catacombs, and, in less quantity, in the Alice and Gwendoline caves, were probably rounded in Glacial times; and many of the limestone pebbles from the outer parts of the Catacombs bear conspicuous striæ due to ice-action. There is little doubt, moreover, that the sand and gravel found in the Bats' Cave was washed in from ice which formerly occupied the low ground of Ballybeg Lake. The other detrital blocks consist of angular limestone that has fallen from the roof, with some residual chert. The secondary products are occasional minute crystals of quartz in the clay of the Alice Cave, left from the solution of the limestone; gypsum in crystalline aggregates (Catacombs); calc-tufa; and oxides of iron and manganese.

The deposits in the Catacomb Cave are remarkable for the amount of staining by oxide of manganese, this material being deposited not only on the surfaces of bones, but in a concretionary and encrusting manner on ferruginous or clayey masses, associated with the more impure calc-tufa. The stalagmite itself occasionally includes black lumps of manganese oxide, which deceptively resemble charcoal. The true charcoal present is, however, distinguished by its woody fibres. Manganese thus occurs in the "Broadway" deposits, and charcoal in the "Cross Gallery."

A white, cream-coloured, or yellowish substance, frequent in small lumps and flakes in the sands and clays of the second stratum of the Catacombs, has proved so far puzzling, though its form and its association with bones make it probable that it is derived from the decay of bone-fragments. Dr. J. Holms Pollok, F.I.C., and Mr. C. W. Courtney, A.R.S.M., have kindly examined it qualitatively, and report that it is a phosphate, but with some alumina and silica. Some specimens become coloured a deep brown when touched with hydrochloric acid; others only darken slightly. A small amount of calcium carbonate is sometimes present.

The pink clay of "O'Callaghan's Gallery" and the clays of the "Broadway" in the Catacombs are full of casts of vegetable fibres.

The second stratum of the "Entrance Gallery" contains a limestone-gravel embedded in brown calc-tufa, with well-glaciated stones. The "Cross Gallery" has large pebbles of grit of various colours, probably also from Glacial drift. There is, as previously remarked, no good evidence as to whether these stones penetrated the caves in Glacial times, or were introduced through fissures afterwards.

4. ANIMAL REMAINS (except Birds).

By R. F. Scharff, PH.D., B.SC.

Mollusca.

The Mollusca obtained in the Edenvale and Newhall Caves are few in the number of species, though they are represented by a fair number of specimens. Not only were land and fresh-water shells found in the caves, but also a few marine ones, which, of course, have been transported into the caves. To judge from the small number of specimens and their worn condition, it seems likely that some of the shells were brought in the crops of birds. Very great quantities of bird-bones have been taken in the caves; and many of the birds to which they belonged must have had their crops full of miscellaneous food. A few shells would probably be

found among such food, as most birds are very keen after lime. However, whether Man was responsible for their presence or birds, does not matter very much, since the presence of Man in the caves is conclusively proved by other facts. In the Alice and Gwendoline Caves, a single specimen of the small fresh-water shell, *Bythinia tentaculata*, occurred in the second stratum along with the Arctic Lemming and some birds' bones. As this species is too inconspicuous and small to have been used as human food, it was clearly brought in by some bird in the way suggested.

Only once before has a list of Mollusca appeared in connexion with Irish cave explorations, viz. in the Report on the Caves of Kesh, previously cited. I am indebted to Mr. A. R. Nichols for assisting me in naming the marine species.

The following is a list of the species obtained in the caves:—

Species.	Alice and Gwendoline Caves.	Catacombs.
	Upper Stratum.	*Upper Stratum.*
Vitrea (Hyalinia) cellaria, ...	common	common
Pyramidula (Helix) rotundata, ..	rare	—
Hygromia (Helix) rufescens	rare	—
Helix nemoralis, ...	common	common
,, aspersa, ...	rare	—
Clausilia bidentata, ...	rare	rare
Cochlicopa lubrica, ...	—	rare
Patella vulgata, ...	1 specimen	2 specimens
Trochus umbilicatus, ...	—	1 specimen
Ostrea edulis, ...	—	2 single valves
	Lower Stratum.	*Lower Stratum.*
Limax maximus, ...	—	rare
Vitrea (Hyalinia) cellaria, ...	common	common
Pyramidula (Helix) rotundata, ..	rare	—
Helix nemoralis, ...	rare	common
,, aspersa, ...	rare	—
Bithynia tentaculata, ...	1 specimen	—
Littorina littorea, ...	—	2 specimens

Species.	Newhall Caves.	
	Upper Stratum.	*Lower Stratum.*
Vitrea (Hyalinia) cellaria, ...	common	—
,, ,, crystallina, ..	rare	—
Pyramidula (Helix) rotundata, ..	rare	—
Hygromia (Helix) hispida, ..	rare	—
Helix nemoralis, ...	common	—
,, hortensis (?), ...	rare	—
,, aspersa, ...	common	—
Clausilia bidentata, ...	rare	—
Pupa cylindracea, ...	rare	—
Acicula (Acme) lineata, ...	rare	—
Carychium minimum, ...	rare	—
Mytilus edulis, ...	rare	a single fragment
Ostrea edulis, ...	rare	—
Patella vulgata, ...	common	—

Fishes.

Edenvale Caves.

As regards the fish remains, my assistant, Miss Stephens, aided me in their determination. A hyomandibular (E. C. 7), from the surface-stratum of the Catacombs, belongs, undoubtedly, to a Codfish (*Gadus morrhua*). It looks recent, and might possibly have been dragged into the caves by some cat or dog from the refuse-heap of Edenvale House.

One fish-fragment from the Alice and Gwendoline Caves was not determinable; but a portion of a jaw (E. A. 87) was identified as that of a large Wrasse (*Labus maculatus*). Another small bone (E. A. 86) possibly belongs to the same species. The Wrasses are not fish eaten by anyone, except some of the poorest fishermen along the west coast; and from that fact alone these remains presumably date back to a much more ancient period than that of the Cod, though found in the surface-layer.

Newhall and Barntick Caves.

Only a few opercular bones, which were not specifically identifiable, of a large fish occurred in the Newhall Caves. In the Barntick caves, a mandibular fragment (C. B. 3) was found, which Miss Stephens considered to be that of a small Gadoid, that is to say, one of the Codfish tribe.

AMPHIBIANS.

No other Amphibian but the Frog was found. That it is not a recently-introduced species in Ireland, but a true native, has been maintained by the writer as the result of the investigation of the Kesh Caves (p. 183).

Frog remains are exceedingly abundant in the Edenvale Caves; though, as has been pointed out before in the pages of this report, the strata are so much mixed that too much reliance as to antiquity cannot be placed on the occurrence of bones in the lower layer of the deposits.

Alice and Gwendoline Caves.—Out of the 88 bags from the upper layer which were examined, 46 yielded Frog remains; while of the 86 bags from the lower layer, 19 contained bones of the same species.

The Catacombs.—In the 246 bags which contained upper layer remains, Frog bones were found in 67; and the 114 bags from the lower layer had such in 14 of them.

Newhall and Barntick Caves.—Both of them yielded Frog remains in the upper and lower strata.

MAMMALS (exclusive of Man).

DOMESTIC PIG (*Sus scrofa domesticus*).

Edenvale Caves.

To discriminate between the earlier varieties of the Domestic Pig and the wild form, is difficult—because the former were at first kept in a semi-feral state, and had probably, to a great extent, to search for their own

food in the forests. Later on, when they were kept under entirely different conditions, the shape of the skull, the teeth, and all the bones of the skeleton underwent profound modifications as the result of the change in life.

A modern breed of pig is therefore readily distinguishable from a wild one. No perfect skull has been obtained in the caves, but very numerous remains of pigs of all ages, showing indications that this species had, for long ages, formed the favourite food of the early races of Man which had formerly inhabited the caves.

Altogether, Domestic Pig remains have been noticed in the caves in a large number of the bags into which, as I explained, the bones were put.

	Upper Stratum.	Lower Stratum.
Alice and Gwendoline Caves, ...	in 56 bags.	in 6 bags.
Catacomb Caves, ...	,, 82 ,,	,, 15 ,,
Newhall and Barntick Caves, ...	,, 112 ,,	,, 15 ,,

As far as could be ascertained, the Pig remains almost all belong to what is known as the old "greyhound race," a long-legged creature now quite extinct in this country. Evidence of the existence of a cross-breed between this old form and a more modern breed could also be established in a few instances.

Newhall and Barntick Caves.

Among the ordinary Domestic Pig, the old and young of which were exceedingly abundant, I met here with the remains of a remarkable dwarf race of Pig:—distal part of humerus (N. H. 119, N. H. 86); prox. part of radius (N. H. 125, N. H. 64); pelvic fragment (N. H. 88).

WILD PIG (*Sus scrofa ferus*).

Edenvale Caves.

I have alluded above to the difficulty in distinguishing the Wild from the Domestic Pig remains, and, when in doubt, have always referred them

to the latter. But there is a pelvis (E. C. 100) and also a humerus (E. C. 340) which I feel sure must have belonged to a powerful Wild Boar. In the Alice and Gwendoline Caves, there were found several tusks which have the dimensions of those of Wild Boars (E. A. 14, 86, 88, and 112), as also two molars (E. A. 63 and 85).

We know from historical evidence that Wild Swine were formerly abundant in Ireland; and such, as well as other game, must have been frequently brought to the caves by the old hunters who inhabited them.

Newhall and Barntick Caves.

Here, also, Wild Pig remains were met with. These were, as a rule, rather smaller than those of the recent European Wild Swine; but a tibia (N. H. 39) exceeds in size a similar bone with which I compared it. Certainly belonging to the wild form are some canine teeth (N. H. 2, N. H. 64, N. H. 29, N. H. 9, and N. H. 122) and also four humeri (N. H. 2, N. H. 20, N. H. 24, and N. H. 78). One of the latter had been in the fire, and seemed also to have been split as if for the extraction of its marrow; while others showed traces of having been gnawed by wolves or dogs.

RED DEER (*Cervus elaphus*).

Alice and Gwendoline Caves.

The remains of this deer were few in number, and very fragmentary. Three particularly ancient-looking fragments were found in the lower stratum—two of them along with the bones of the Arctic Lemming. All the remainder had a modern appearance, though it is probable that the Red Deer had ceased to exist in the neighbourhood of Edenvale since the beginning of the last century.

The Catacombs.

Red Deer remains are very abundant in the Catacombs. They occurred in 84 bags out of the total 362 which were collected from the

deposits of this cave. Many of the remains were little injured, but showed marks of teeth, as if they had been dragged into the caves by dogs or wolves; others had apparently been split open by Man for the purpose of obtaining the marrow.

As regards the size of the old Irish Red Deer, which is now practically extinct in Ireland as a wild animal, some of the long bones, evidently those of old males, were of large size. They approached those of an ordinary female Wapiti Deer. The following are the sizes of the largest I measured:—

Right tibia (E. C. 145),	...	343 mill.	in length.
,, metacarpal (E. C. 117),	...	258 ,,	,,
,, metatarsal (E. C. 236),	...	286 ,,	,,

Newhall and Barntick Caves.

Some of the specimens discovered in these caves may eventually be found to belong to a distinct species of deer. For example, three fragments of an antler (N. H. 77 and 78) had a single brow-tine near the base; and from it the main stem extended straight out for fully 10 inches without giving off any additional tines—a condition resembling that seen in some of the Indian Deer. A lower jaw-fragment, with two posterior molars, also differs from that of the ordinary Red Deer (N. H. 207). Future researches may throw light on these peculiar forms.

There are both young and adult Red Deer remains in quantity in the caves, some of them being very large—one metacarpal was no less than 269 mill. long (N. H. 139), which is of very unusual dimensions for a Red Deer, while a right metatarsal (N. H. 86) measured 287 mill. in length, and a tibia 347 mill.

IRISH ELK (*Cervus giganteus*).

Edenvale Caves.

The remains consist mostly of much-blackened fragments of bones, indicating great antiquity; but there are some, such as a broken left

calcaneum (E. C. 59), which looked quite fresh, exactly like the bones of the domestic animals among which it was found in the surface-layer.

Other very recent-looking fragments of considerable interest were found in the first cross-gallery of the Catacombs, in a thick seam of tufa, about 18 inches below the surface. They consist of portions of a shed antler (E. C. 18). Since the antler had evidently been shed before death, there appears to be no reason why any animal should have carried the indigestible and unattractive morsel into the cave. It may, of course, have been washed in from above; but it seems more likely that it was brought in by early Man, who used it for the manufacture of bone-tools, for which the hardness of the antler is particularly suitable. These are, however, not the only indications of Man's contemporaneousness with the Irish Elk in Ireland. Professor Leith Adams long ago concluded, from the occurrence of longitudinally-split bones of the Irish Elk along with hammer-stones in Ballinamintra caves (p. 200), that Man had hunted the Great Deer in this country, and had smashed the long bones afterwards for the extraction of the marrow.

In some instances—for example, in a phalanx (E. C. 324)—the marks of the teeth of a large Carnivore were clearly visible, and there were many apparently artificially-fractured bones, such as one commonly meets with in kitchen-middens and surface-deposits of caves.

One of the most remarkable results of the cave-excavations at Edenvale is the establishment of the fact that Irish Elk remains occur in the Catacombs more abundantly in the upper layer than in the lower. I have again and again had to draw attention, in this report, to the occurrence of blackened and ancient-looking remains in the surface-stratum, owing to the Badgers having made extensive burrows in the caves; but it is impossible that they should actually have reversed the order of things to such an extent that more ancient bones should be found above than below. No less than twenty of the bags which had been filled with bones from the upper stratum contained Irish Elk bones, and only eleven of the bags from the lower layer.

As regards the Alice and Gwendoline Caves, one bag only from the upper, and eleven from the lower, layer contained remains of the Irish Elk.

Newhall and Barntick Caves.

The Irish Elk was rare in the Newhall, and altogether absent in the Barntick Cave. Eight bags from the lower, and three from the upper contained the remains of this magnificent deer. Most of the bones had the appearance of great antiquity; but a phalanx from the lower stratum (N. H. 222) was fresh-looking.

Reindeer (*Rangifer tarandus*).

Edenvale Caves.

Reindeer remains have been obtained in the Shandon Cave, County Waterford, and in the caves of Kesh, County Sligo; and now here again, in the caves of Clare, we have abundant evidence that this species inhabited the country formerly. However, all but two phalanges (viz., E. A. 15 and E. A. 176) are dark in colour, with the characteristic brighter markings which indicate great antiquity. It is to be presumed, therefore, that the Reindeer has been extinct for a long time in this country. Moreover, most of the bones are well preserved; and none of them show clearly that the Reindeer had been used as food by Man. The fact that again and again the remains of this deer are associated with those of the Bear and Irish Elk, and that all these are similar in colour, would seem to point to their having inhabited Ireland at the same time.

Three of the bags containing material from the upper stratum of the Alice and Gwendoline Caves, and nine bags of the same stratum from the Catacombs, contained Reindeer remains. The fact clearly shows what a large disturbance in the deposits these caves have undergone, as all these bones must originally have been in the lower stratum.

Newhall and Barntick Caves.

No remains of the Reindeer have been found in the Barntick Caves, while in the Newhall Caves they occurred sparingly. The long bones

were mostly broken, as if for the purpose of obtaining the marrow; and a few of the bones had the appearance of having been in the fire (N. H. 181 and 200). Only two portions of a radius are recent-looking, and they occurred in the upper stratum (N. H. 113 and 148); all others are reddish-coloured and look ancient. A few bones belong to young individuals.

Goat (*Capra ægagrus*).

Edenvale Caves.

Goat remains occurred chiefly in the upper stratum—in fact, only two of the lower-deposit bags from all the caves yielded undoubted Goat remains, though eight others contained bones referable to Goat or Sheep. The Goat agrees in its general character with that living in Ireland in a semi-feral state in the mountains at the present day.

Thirty bags from the Catacombs and three from the Alice and Gwendoline Caves, containing upper stratum material, yielded Goat remains; and eighty other bags from the same stratum, Goat and Sheep mixed.

Newhall and Barntick Caves.

Both upper and lower strata yielded Goat remains in abundance. None of those found in the latter exhibited signs of great antiquity.

Sheep (*Ovis aries*).

Alice and Gwendoline Caves.

In the Report on the Kesh Caves I have already referred to the extreme difficulty experienced in separating the Sheep bones from those of the Goat. The skull is scarcely ever preserved, and the teeth and bones of the Sheep commonly found in the caves are very Goat-like. Almost all the remains that came under my observation belong to a race which we also find in crannogs, such as that of Dunshaughlin and others—a small race, with thin, long legs, which still exists at the present day almost

unaltered, on the small island of Soa off the west coast of Scotland. Another closely allied race is that which inhabits the island of St. Kilda. Apart from its small size, the Sheep has many Goat-like features. Among the bones and teeth discovered in the Alice and Gwendoline Caves, the Sheep was identified in many cases—the Goat in very few; while nineteen bags contained remains which I could not separate. They were either those of a Sheep or Goat. Of course many of the remains belonged to young individuals, or were very fragmentary, when the labour of identification is much increased.

Only two of the bags from the second stratum contained Sheep remains; and these were recent-looking, and may have dropped down from the upper.

The Catacombs.

The above remarks likewise apply to this cave, except that we have here also represented a much larger race of Sheep, which may be quite a modern introduction, whose remains were met with in nine of the bags (viz., E. C. 2, 4, 7, 8, 95, 236, 237, 325, 338). Only four of the second-stratum bags contained Sheep remains, and none of these bore signs of antiquity. Sixty-one of the upper-stratum bags yielded Sheep remains.

Newhall and Barntick Caves.

Most of the Sheep remains belonged to individuals much smaller even than the St. Kilda race with which they were compared; though a few bones of a modern breed of sheep were found (*e.g.*, N. H. 176). A large number of teeth and bones could not be named with certainty. They belonged to Sheep or Goat.

HORSE (*Equus caballus*).

Edenvale Caves.

None of the Horse remains have a particularly ancient look about them; and they can probably all be referred to domesticated specimens.

The remains consisted of teeth and broken bones, principally of young Horses which may have been used for food.

The Horse remains indicate that the race of Horses in the neighbourhood of the caves was, until recent times, small, not exceeding in size an ordinary Connemara pony. Only a single bone (the right os magnum) belonged to a larger race of Horse. This may be quite modern; at any rate, it occurred on the surface-layer of the Entrance Gallery of the Catacombs (E. C. 300). Two upper molars found in the Alice and Gwendoline Caves (E. A. 86) were remarkable for the fact that the enamel was devoid of the peculiar equine loop, as is the case in the teeth of the Ass. If it were not for the size of the teeth, I should be inclined to refer them to the latter species.

Newhall and Barntick Caves.

The remains of foals were found in twelve bags, and those of adult horses in sixteen, all but one being from the upper stratum. As in the case of the Edenvale Caves, the bones were much broken, as if they had been used for food; and they all belonged to specimens of the size of a Connemara pony or smaller.

Ox (*Bos taurus*).

Edenvale Caves.

Most of the bones and teeth of the Ox are those of young individuals; and many were split as if for the extraction of the marrow, and some were charred as if they had been in the fire.

None of the bones are blackened like those usually found in older deposits, and there is no reason to suppose that the Ox was contemporaneous in Ireland with the Irish Elk, Reindeer, and other extinct animals.

Remains of the Ox are abundant in both series of the Edenvale Caves; and the remarkable point noticed is that the bones seem to belong exclusively to a small race such as the breed known as the "Kerry."

But the long bones are somewhat more slender in the cave Ox than in the modern breed, and the toes rather shorter and narrower.

Newhall and Barntick Caves.

Almost all the bones and teeth found agree in general structure with the Kerry breed; but the teeth and toes are narrower and smaller, as already observed, in the Edenvale remains, and the long bones more slender. The ancient breed thus approaches in some respects the Deer in structure; and the bones are sometimes difficult to distinguish from those of the latter. Many bones were artificially fractured; while some were cut by a knife or saw (N. H. 1, 18) (rib of larger modern breed, N. H. 91), and others greatly gnawed by large carnivores—perhaps by Wolves.

Ox remains occurred in ninety-six bags of the upper, and in ten bags of the lower stratum. I think few, or none, of the latter were originally in that position, to judge from their appearance.

The Arctic Lemming (*Dicrostonyx torquatus*).

The Catacombs.

This species was first discovered in Ireland in 1901, and fully described in the Report on the Kesh Caves (p. 196).* It was the size of a large mouse with a very short tail and thick, woolly fur.

Only in three of the bags were a few of the remains of Lemming found; and but one of these came from the second stratum. The other two occurred along with the Sheep, Fox, Red Deer, and Rat; and one of them—half a lower jaw—is so extraordinarily fresh-looking, that it might easily be taken for a recently macerated specimen.

Alice and Gwendoline Caves.

No less than a dozen bags contained Lemming remains, most of which belonged to young individuals. Of these only three were found in the

* *Loc. cit.*

second or lower stratum; and most of the bones had the appearance of such as are generally met with in the upper layer.

Newhall Caves.

Only a femur and a left ramus of a mandible were found in the Bats' Cave. These came from the upper stratum (N. H. 118), and were as recent-looking as the bones of domestic animals which may have been introduced into the caves only a few years ago.

FIELD MOUSE (*Mus sylvaticus*).

Edenvale Caves.

This species was fairly abundant in all the caves; and its remains were met with in both the upper and lower strata. It has also been found in Ballinamintra Cave (Co. Waterford) and at Kesh (Co. Sligo), and is no doubt an ancient inhabitant of Ireland.

Newhall and Barntick Caves.

Remains of the Field Mouse occurred, but were very rare, having been met with in only six bags, five of which belonged to the upper stratum.

IRISH RAT (*Mus decumanus hibernicus*).

The Catacombs.

Rat remains were found in sixteen of the bags which were collected from the upper, and in six from the lower, stratum. Yet none of the latter bore any signs of antiquity. A few of those occurring in the upper layer were stained brown, showing that they had been there for a considerable time—perhaps some centuries. Many of the remains belonged to old and greatly diseased individuals; some had lost most of their teeth. A few young rats occurred.

The remains were carefully compared with recent specimens of the Irish Black and Brown Rats, and agreed with them in every respect. There is apparently no difference at all in the skulls of the Irish Black and the Irish Brown Rat; but I noticed that, whereas in all of the Irish skulls the supra-occipital was much bent forward, and the anterior margin of the maxillary part of the zygomatic arch was straight, in English and Continental skulls of the Brown Rat, the supra-occipital is usually not bent forward, and the portion of the zygomatic arch referred to is curved. Among a large number of skulls I found it possible, as a rule, to pick out the Irish by these characters.

There exists in Ireland, also, though very rarely, the small, long-tailed Black Rat (*Mus rattus*), which I believe I have identified from the Newhall Caves.

Alice and Gwendoline Caves.

Here, too, many diseased specimens were found. All the remains occurred in the upper stratum; altogether in twelve bags.

In connexion with the questions of the introduction of the Rat into Ireland, it is interesting to note that Shakespeare referred to the "Irish Rat" in one of his plays ("As You Like It," Act iii., sc. 2), whereas the ordinary Brown Rat is supposed only to have been introduced into England in the eighteenth century.

Newhall Caves.

Forty-two bags yielded Irish Rat remains, two of which came from the lower stratum. Some of them looked greatly discoloured, and may be ancient.

Black Rat (*Mus rattus*).

This rat is not to be confounded with the Irish Black Rat, referred to above. A skull fragment and some long bones appeared to agree better with the Black Rat than the Irish Rat. They were found in the Newhall

Caves (N. H. 54, 64, and 65) in the upper stratum. As mentioned before, this species occurs in Ireland at the present day, but it is very rare.

Irish Hare (*Lepus timidus*, L. = *L. variabilis*, Pall.).

The Catacombs.

Hare remains were very numerous; and to judge from their excellent state of preservation, a large number of Hares seem to have died a natural death in the Catacombs. The great majority of them, however, were gnawed and broken, showing that they were largely used as food.

As far as possible the cave bones and teeth were compared with those of recent specimens of the Irish Hare, and of the English Hare (*Lepus europæus*); but none of the remains agreed with those of the latter species. It is probable, therefore, that the English Hare, since it is not now found in this country, was never an inhabitant of Ireland.

The upper stratum, as far as could be determined, yielded Hare remains in 107 of the bags examined, and the lower in eighteen of them. In both strata there occurred a number of bones which bore traces of considerable antiquity, such as dendritic markings and general discolouration.

For the purpose of further comparing the cave bones with those of a recent Hare, a recent disarticulated female specimen (354 *a*, 1901) from Roscommon was selected. It is interesting to note that of ten complete cave tibiæ measured, four were smaller than the recent tibia; of five complete femora measured, all were considerably longer than the recent femur; and of eight humeri, all were also much longer than the recent humerus. This fact seems to indicate that the upper portions of both front and hind limbs have become shortened in the Irish Hare in course of time, possibly owing to change of habit. I have no doubt that the remains of a large hare which have been referred by Sanford* and others to a new species, *Lepus diluvianus*, Pictet, really belong to this species, and

* Sanford, W. A., "On the Rodentia of the Somerset Caves." Quart. Journal Geol. Soc. of London, vol. xxvi. 1870.

not to *L. europæus*. The skull figured by Sanford very little exceeds in size some of those found in the Edenvale Caves, and the depression in the malar bone and other characters, by means of which he distinguishes *L. diluvianus* from *L. timidus* (= *hibernicus* = *variabilis*), p. 127, agreed with such in skulls of the latter species examined by me. Trouessart, in his Catalogue of Mammalia, refers to *L. diluvianus* as a form of *L. europæus*.

Alice and Gwendoline Caves.

The Hare remains in these caves were much more broken and gnawed than the others; and in one instance knife-incisions were found on a pelvic fragment, pointing to Man having used the flesh for food. The remains occurred in both strata, which had been much disturbed; but of a dozen greatly discoloured and blackened bones picked out among the Hare bones, eight had been discovered in the second stratum or clay, and four in the surface stratum, so that signs of great antiquity seem to occur about twice as frequently in the lower stratum as in the upper.

Newhall and Barntick Caves.

There were a large number of uninjured long bones in these caves in both upper and lower strata. The femora varied in size from 117–131 mill.; the tibiæ from 129–149½ mill.; the humeri from 100–109 mill.

RABBIT (*Lepus cuniculus*, L.).

The Catacombs.

Rabbit remains were exceedingly numerous in the Edenvale Caves. Mr. Ussher informs me that he thinks the caves were inhabited by Rabbits when clear of Foxes. But Foxes, Badgers, Martens, and even Dogs and Cats, no doubt, brought in many Rabbit corpses to devour them at leisure. I have already expressed the view on a previous occasion that I thought the Rabbit was probably indigenous to the British Islands (*cf.* Exploration

of the Caves of Kesh, p. 200). Nothing, however, had hitherto been found to confirm this opinion. Only a few fragments of Rabbits had so far been discovered in the older strata of other caves, which contained also remains of extinct animals. Of the 114 bags of bones, however, which contained materials collected from the lower or second stratum, thirty-one yielded Rabbit remains, and nine of these presented unmistakable signs of antiquity. It may be asked, why should not all the bones in the second stratum show such marks? Because Badgers and other burrowing animals already referred to greatly disturbed the strata, so that many, no doubt, of the Rabbit remains now in the second stratum have slipped in from above.

Mr. Sanford (p. 128), who made a special study of the cave rodents, is of opinion that considerable doubt must still exist as to the Rabbit having been really contemporaneous with the Mammoth in these islands.* Yet he acknowledges that he has seen Rabbit remains from Wookey Hyæna den, from Hutton and from Kent's Hole, which were apparently in the same state of preservation as the remains of extinct animals.

As regards the size of the Rabbit in past times, the extremely large number of long bones has enabled me to make some comparisons which appear to me of interest.

Of the cave femora examined, the great majority were slightly smaller than that of a recent female in the Museum collection (100, 1899); while all the cave humeri were much shorter than the recent. The cave tibiæ were mostly somewhat shorter than the corresponding recent parts. It would seem, then, as if the Rabbit had increased in size in recent times, especially in the front limbs, indicating an increase in its running powers.

Alice and Gwendoline Caves.

As in the Catacombs, so also in these caves, a number of Rabbit remains were found in the second stratum, some of which were blackened. The results of the measurements taken quite agreed with those above referred to. While the parts of the hind limbs were about the same or

* Sanford, W. A., *op. cit.*

only slightly shorter than in the recent specimens, the front limbs were much shorter formerly.

Newhall and Barntick Caves.

Also, in these caves, Rabbit remains were abundant in both strata. Sixty-six bags from the second stratum of the Newhall Caves yielded Rabbit bones in nineteen of them; yet they all were modern-looking, and most of them probably had dropped in from above. Mr. Ussher thinks Rabbits had burrowed in and died there. Fifty-one complete femora measured from 79–86½ mill. in length; forty-one humeri from 61½–68 mill. in length; and seventy tibiæ from 87–98½ mill. in length.

IRISH STOAT (*Putorius ermineus hibernica*).

Edenvale Caves.

The Stoat-like remains found in the Edenvale Caves confirm the view expressed in the Kesh Report (p. 205) that the jaw discovered at Kesh along with Lemming and Field Mouse remains is that of a very small Irish Stoat, and not that of a Weasel. Two extremely small femora, 26½ mill. long, were met with, one in the Catacombs (E. C. 335), and the other, a broken one, in the Alice and Gwendoline Caves (E. A. 36). These are slightly longer than the femora of average Weasels, and agree in their general appearance and slenderness with those of female Irish Stoats.

Besides these there was a small pelvis (E. C. 335), a femur 30½ mill. long (E. A. 26), two humeri (E. A. 87 and 89), and a canine tooth (E. C. 92). All these were found in the upper stratum of the caves, and have the appearance of fairly recent bones.

Newhall Caves.

All the remains of Stoat were found in the upper stratum, and agreed in size with the Irish Stoat, varying much as recent specimens do of males and females, except in one instance. This is a recent-looking humerus (N. H. 19), which occurred together with Man and domestic

animals, yet differed from all other Irish Stoat remains in its great size. It measured 37 mill. in length, and is therefore fully as long as that of a male English Stoat.

Marten (*Mustela martes*).

Messrs. Woodward and Sherborn's record (p. 368)* of the Marten as having occurred in the Shandon Cave is an error. It should read "Ballinamintra Cave," where some fresh-looking remains of this small carnivore were found by Mr. Ussher.

The Catacombs.

In the Catacombs, the Marten was met with in twenty bags, several of which were found in the second stratum, and contained rather old-looking bones. The great majority had a fresh appearance, and were uninjured. Some belonged to young individuals.

Alice and Gwendoline Caves.

Eight bags contained Marten remains, and some of the latter had an ancient appearance, though all occurred in the upper stratum.

Newhall and Barntick Caves.

Most of the remains found were of large dimensions, like those of recent male Martens. They occurred in twenty-three bags, of which two were obtained from the lower stratum.

Mr. Ussher informs me that Martens were formerly numerous in the district, where they were hunted by members of the Edenvale family.

Otter (*Lutra lutra*, L.).

In the Newhall Caves the remains of at least three individuals of the Otter were discovered, most of them being limb-bones. All but two of

* Woodward and Sherborn: A Catalogue of British Fossil Vertebrates. London, 1890.

these occurred in the upper stratum. A lower canine tooth and a radius were found in the second layer.

The Otter has not previously been met with in a fossil condition in Ireland. It is an ancient inhabitant of England, having been traced as far back as the Norwich Crag, which is of Pliocene age. It is therefore probable that it came to Ireland long before the Glacial period.

Badger (*Meles taxus*).

Edenvale Caves.

It has already been noticed that the Badger had mixed the strata in the caves to such an extent as to greatly reduce the value of the scientific results obtained from this cave exploration. Until quite recently, Badgers, no doubt, inhabited the caves, and may have devoured some of the smaller Mammals there, of which we find the remains. Bones belonging to individuals of all ages, and about a dozen perfect skulls, were found; as also hardened masses, probably Badger excrements, composed of pellets of clay, vegetable fibres, and the remains of beetles.

Altogether, Badger remains were extremely abundant in the caves, much more so, however, in the Catacombs than in the Alice and Gwendoline Caves. The 246 bags collected in the upper stratum of the former yielded remains of that Mammal in ninety bags; while eighteen of the lower stratum bags contained Badger remains. Only nine bags of the upper stratum, and one of the lower, in the case of the second series of caves, contained Badger remains.

Many of the bones of this species are uninjured and in an excellent state of preservation, so that I have been able to take numerous measurements of the long bones.

Twenty-three perfect humeri from the Catacombs and the Newhall Caves varied in their extreme length from 99·5 mill. to 116·5 mill., that is to say, within 17 mill. A recent male humerus in the Museum measured 103·5 mill. The majority of the cave humeri were somewhat larger than those of the recent specimen.

Twenty-seven perfect femora were measured from the Catacombs and the Newhall Caves; and these varied between 107·5 mill. and 120 mill., that is to say, within 12·5 mill. A recent male femur in the Museum measured 112·5. The majority, also, of the cave femora are larger than the recent one. It would seem, therefore, as if the size of the Badger had decreased in recent times.

According to Prof. Owen, Badger remains have been discovered in English cave deposits, along with the Cave Bear, Hyæna, and Tiger, and manifesting precisely the same mineral conditions, so as to leave no doubt of their equal antiquity. In Ireland also, I think, this species is probably a very ancient one. Some of the bones are in the same condition and of the same colour as those of the Reindeer.

Newhall and Barntick Caves.

The bones and teeth of both old and young Badgers were very numerous indeed in these caves, many skulls and long bones being in a perfect state of preservation. They occurred in the upper stratum in ninety-nine bags, and in the lower in eight. The length of the humeri varied from $98\frac{1}{2}$ to 116 mill., and that of the femora from 105 to $127\frac{1}{2}$ mill. We have therefore in these caves a greater variation in the size of the Badgers than even in the Edenvale Caves. Some of the specimens whose remains were left in these caves must have been of unusually large dimensions.

BEAR (*Ursus arctos*).

Edenvale Caves.

There is no skull of the Bear among the Edenvale Cave remains, nor even a complete lower jaw, so that it is impossible to determine with certainty whether some of the bones may not have belonged to the Great Cave Bear rather than to the ordinary Brown Bear. But all skulls of Bears hitherto found in this country agree in their main characters with those of the Brown Bear. I have no hesitation in referring the remains which were discovered in these caves to the same species.

Some of the bones, such as the radius and ulna (E. C. 362), discovered in the upper stratum of the Catacombs along with the remains of the Irish Elk and Reindeer, are extremely large; and so is a metatarsal (E. A. 93) from the Alice and Gwendoline Caves.

Most of the bones are blackened; but some are recent-looking, and have been obtained in the upper stratum along with the remains of domestic animals and charcoal. A molar (E. C. 270) was actually partly enveloped in charcoal. To judge from the remains generally, it seems to me that the Bear did not always inhabit the caves, but was sometimes hunted by Man and used for food. A knee-cap of a large Bear (E. A. 131) shows clearly the incisions of a knife, which was probably used to divide the tendons which keep that structure in position. Altogether, the Bear remains met with in the Alice and Gwendoline Caves have a much more recent aspect than those found in the Catacombs, and would tend to show that Bear-hunters inhabited the former cave after the other had been forsaken. Some of the bones, especially a metatarsal (E. A. 63), had been gnawed by a large carnivore, though there is nothing to point to the Hyæna having inhabited the country at that time.

The remains of both very old specimens and quite young cubs were met with. Twenty-seven bags from the upper stratum of the Catacombs, and sixteen from the Alice and Gwendoline Caves, contained Bear remains. As regards the lower layer, twenty-five bags from the Catacombs and forty from the other caves, in a similar manner, indicated the presence of the Bear.

Newhall and Barntick Caves.

No Bear remains were found in the Barntick Caves. In the others they occurred sparingly, and in a very broken condition in both layers. In a lower and an upper jaw (N. H. 129 and 135) the milk-teeth had not yet appeared above the gums. It seems as if these parts belonged to an unborn Bear cub, whose mother had probably been killed, and the remains scattered about in the cave.

Dog (*Canis familiaris*).

Edenvale Caves.

There are no reliable characters by which individual bones of the Dog can be distinguished from the Wolf; but we have fortunately a few almost complete skeletons from the Edenvale Caves which undoubtedly belonged to Dogs; and it is probable that almost all the Dog-like remains discovered are referable to the domestic species.

Only two bones—viz., a metacarpal (E. A. 11) and a lower jaw fragment of a young individual (E. C. 93)—bear signs of antiquity, and may possibly have belonged to Wolves.

A complete skull and leg-bones of a small mastiff-like Dog, probably a female (E. A. 87–89), were found on the surface of the Alice and Gwendoline Caves. The facial angle, which I measured according to the directions given in Prof. Studer's excellent work on the prehistoric Dogs,* measured 52°. Nearer the entrance occurred an almost complete skeleton (except skull) of a Dog resembling the Eskimo breed (E. A. 1, &c.). Another incomplete skeleton of the same breed was discovered in the upper stratum about 10 feet from the entrance (E. A. 34, &c.).

Dogremains occurred in forty bags from the upper stratum of the Alice and Gwendoline Caves. There were very few in the Catacombs. A radius fragment (E. C. 355) and a metatarsal (E. C. 116) might be those of a Wolf. Some of the other bones seem to point to a Dog of the size of an Irish terrier.

Newhall and Barntick Caves.

There are in these caves more pronounced indications of the presence of Wolves. Sixty-eight bags from the upper stratum, and one from the lower, however, contained teeth and bones which seemed to me to belong to Dogs. Whether these were wild or domesticated I am unable to

* Studer, T. Die praehistorischen Hunde in ihrer Beziehung zu den gegenwärtig lebenden Rassen. Abhandl. d. Schweiz. palæont. Gesellsch., Vol. xxviii., 1901.

determine. Twelve other bags from the upper, and one from the lower, included remains which were very Wolf-like; but only in one case could the presence of the Wolf be determined with certainty.

Wolf (*Canis lupus*).

It is unnecessary to repeat the above remarks made under the heading of Dog. It is extremely likely that many of the Wolf-like bones referred to actually belonged to Wolves, as Wolves were abundant in this country until a few centuries ago.

In the Barntick Cave an immature skull fragment was met with (C. B. 7), which had a facial angle of 40°, and therefore certainly belonged to a Wolf. This is the first instance of the discovery of a Wolf's skull in Ireland—a remarkable fact, considering the former great abundance of this carnivore in this country.

Fox (*Vulpes alopex* = *Canis vulpes*).

The Catacombs.

This is one of the commonest species in both layers in the Catacombs. The remains are, as a rule, unbroken, and include both young and adult, showing that for long periods Foxes inhabited the caves.

Of twenty-one bones which I picked out as being particularly ancient-looking (they were all mottled, and like the Reindeer bones in appearance), ten were found in the lower stratum, and eleven in the upper. Fox remains occurred altogether in 124 bags, out of 362 which were sent to the Museum from these caves.

To judge from the fact of the occurrence of the Reindeer and Arctic Lemming in these caves, it seemed probable that the Arctic Fox (*Vulpes lagopus*) might also have been an inhabitant of Ireland in former times. I therefore carefully compared all the Fox remains with the skeleton of the Arctic Fox in the National Museum, and find that some of them agree

in size with the latter species. It may be of interest to give the measurements of a few of the bones:—

	Recent ♀. 33. 1900.	Recent ♀. 211. 1902.	Fossil. E. C. 323.	Fossil. E. C. 361.	Fossil.	Fossil.
Length of Humerus,	123 mill.	124 mill.	123½ mill.	103½ mill.		
			E. C. 335.	E. C. 89.	E. C. 116.	E. C. 311.
Length of Femur, .	—	131½ mill.	117 mill.	130 mill.	118½ mill.	115 mill.
	Recent Arctic. 335. 1904.		E. C. 237.	E. C. 360.	E. C. 54.	
Length of Tibia, .	128 mill.	137 mill.	126 mill.	114½ mill.	112 mill.	

The Arctic Fox skeleton referred to (335, 1904) is unfortunately incomplete; and the sex is unknown, but Mr. Newton gives us the sizes of the long bones of both a male and female,* so that we are able to compare our bones with them. One of the tibiæ (E. C. 54) is actually smaller than Mr. Newton's tibia of a female Arctic Fox, yet there are great variations in size of Foxes living in Ireland at the present day; and I would hesitate in referring any Fox bones to *Vulpes lagopus* merely because they are very small. The most characteristic differences between the two species are to be found in the last upper and lower premolar, and upper and lower molar teeth. Now, some of the skull-fragments (for complete skulls were extremely rare) were small as compared with a recent female Common Fox. Yet the size and shape of the teeth mentioned were almost identical with those of the latter species; while the last upper premolar and upper molars of the Arctic Fox differ considerably. I am inclined to believe, therefore, that most of these very small Fox remains are referable to a variety of Common Fox.

I may mention that at the present day two forms, a large one and a small one, seem to occur both in Scotland and Ireland; and with us here

*Newton, E. T.: The Vertebrate Fauna from the fissure near Ightham, Kent. Quart. Journ. Geol. Soc., vol. L. 1894.

Foxes whose underside is dark grey like the Mediterranean form are also occasionally taken. One such is in the National Museum collection.

Alice and Gwendoline Caves.

In no less than thirteen bags were found Fox remains smaller than those of the Arctic Fox; but the remarks made upon them likewise apply to these caves. Out of eleven bones picked out on account of their very ancient look, seven were originally found in the upper stratum, and only four in the lower, indicating that considerable disturbance of the strata had occurred before the cave excavations were made.

Newhall and Barntick Caves.

Also in these caves the Fox remains were exceedingly abundant in both layers. The size of the humeri varied between 135½ and 111 mill., the femora between 115½ and 145 mill., and the tibiæ between 120 and 156½ mill. I was fortunate in discovering among the Fox jaws one which is undoubtedly that of an Arctic Fox.

Arctic Fox (*Vulpes lagopus*).

During my investigations of the Fox remains, I had several times come across fragments of long bones which agreed in size with those of the Arctic Fox; but size alone is not sufficient, because small and large varieties of the Fox, even at the present day, inhabit Ireland, and all the teeth agreed in character with those of the Common Fox.

However, a fragment of the left ramus of a greatly discoloured jaw (N. H. 47) which was discovered in the upper stratum of the Elder-Bush Cave, along with undeterminable remains, struck me as differing in character from that of the Common Fox. (Plate IV., fig. 7.) On comparing it with a jaw of *Vulpes lagopus* in the Dublin Museum, I found that it agreed with the latter in the shape and size of the premolars, and in smallness of the molar tooth, so that I had no hesitation in pronouncing the jaw to be that of an Arctic Fox.

As this species is so exceedingly rare in England, and had not previously been known to occur in Ireland, I sent the specimen to Dr. Andrews of the British Museum, and asked him for his opinion. He carefully compared it with a number of mandibles of the Common and Arctic Foxes, and replied that he had no doubt that it belonged to a small breed of the latter species. Dr. Andrews also mentioned that the jaw resembled that of a form from Spitzbergen, which Major Barrett-Hamilton had called *Canis lagopus Spitzbergensis* (Ann. Mag. Nat. Hist., vol. 1 (7th ser.), 1898).

Major Barrett-Hamilton, who happened to be at the British Museum at the time, also wrote to me to confirm this determination.

The jaw has the appearance of great antiquity, and had evidently found its way into the upper stratum in recent times.

Domestic Cat (*Felis domestica*).

The Catacombs.

The Cat remains were mostly unbroken, and probably of fairly recent origin, cats having possibly strayed in during the last few centuries from the neighbouring human habitations. In some cases the skull had been preserved (E. C. 230), and showed the characteristic last upper premolar tooth of the Domestic Cat. Many other remains could only be doubtfully referred to the Domestic Cat, as the differences between it and the Irish Wild Cat were not so apparent. Altogether, undoubted Domestic Cat remains were found in nine bags, one of which belonged to the second stratum, and eight to the first. In sixteen other bags Cat remains occurred which could only be doubtfully referred to the Domestic Cat. Among these, two were from the second layer.

The Alice and Gwendoline Caves.

Only in two bags were remains met with of the Domestic Cat.

Newhall and Barntick Caves.

The Domestic Cat occurred in twenty-four bags, all of which, except two, came from the upper layer. That there has been horizontal as well as vertical disturbance of the remains is shown by the remains of a Cat which suffered from a fractured limb before death. A portion of that limb was found at the mouth of the Bats' Cave, and another at a distance of 34 feet within the cave.

IRISH WILD CAT (*Felis ocreata* = *F. maniculata* = *F. caligata*).

William Thompson ("Natural History of Ireland," vol. iv., 1856) came to the conclusion about fifty years ago that it was uncertain whether the Wild Cat existed in Ireland or no. This alone would seem to indicate that there must have been reports and legends of the former occurrence of this species in Ireland. It must be remembered that some of these reports probably refer to the Marten, which is sometimes spoken of as a "Cat" in this country. Nevertheless the rumours and descriptions from the mountains of Kerry, Galway, and Donegal seemed to point to another creature of the real Cat tribe. So-called Wild Cats which had been taken and sent to naturalists formerly were all put down as being ordinary Domestic Cats run wild, because they had not the bushy tail so characteristic of the Scottish Wild Cat. Had the teeth been carefully examined, it is possible that a difference might have been detected between these so-called Wild Cats and the domestic species. At any rate, a Wild Cat exists in Northern Africa at the present day which has a pointed tail, and the general appearance of a tabby Domestic Cat, and yet differs from the latter in its dentition.

I am glad to be able to report that this Wild African Cat, of which we possess skulls in the Museum, has formerly inhabited Ireland. I have dealt with the subject in a special paper to which I must refer those who desire further information.* Among the numerous Cat remains which

* On the former occurrence of the African Wild Cat in Ireland. Proc. Roy. Ir. Acad., vol. xxvi., sect B, 1906.

Mr. Ussher discovered in excavating the Edenvale Caves and Newhall Caves, there were some teeth, jaw-fragments, and long bones (all from the upper stratum) which seemed to me different from the rest. Most of them belong undoubtedly to the Domestic Cat; but the teeth in five of the bags from the Edenvale Caves agreed in every respect with those of the North African *Felis ocreata* (*maniculata*).*

The most complete evidences of the existence of the Wild Cat in Ireland were a jaw-fragment (E. A. 42) found in the first stratum of the Edenvale Caves, of a reddish tinge, which was embedded in tufa, and a magnificent lower jaw from the Newhall Cave (N. H. 88).

The most characteristic tooth of the wild species is the last tooth in the lower jaw, the lower carnassial or sectorial. I have measured several lower carnassials belonging to Domestic Cat skulls in the Museum; and their maximum length varied from $5\frac{1}{2}$ to 8 mill., while the cave sectorials of the Wild Cat measured from $8\frac{1}{2}$ to 10 mill. in length (Plate IV., fig. 9).

The remains of the Wild Cat have been identified with certainty from the Newhall and Barntick Caves in seven bags. There were Cat remains in 48 other bags, which could not be identified with certainty as belonging to the Wild Cat, but many of them probably do. There is another point of interest in the vertical distribution. All the Wild Cat remains from the last caves were met with in the upper stratum; and 46 out of the 48 other bags came from the same layer, so that we possess evidence from the cave deposits that the Wild Cat lived in Ireland recently, and probably within historic times.

Shrew Mouse (*Sorex minutus*).

The Catacombs.

It is doubtful whether this species has ever been found fossil before in the British Islands. A mandibular ramus from the Forest Bed has

* I referred to this species under the name of *F. caligata* in the preliminary Report read before the British Association in 1904; but it has now been established that *maniculata* and *caligata* are identical, and that the term *F. ocreata*, Gmel., has priority.

been referred to this species, but with a query. Hence the occurrence of this mammal in an Irish cave is of particular interest.

The remains of the Shrew Mouse consist of a somewhat damaged cranium which was found in the Gallery of the Unfortunate Man, near the surface (E. c. 96). It is that of the Pigmy Shrew, which is the only species of the genus inhabiting Ireland at the present time.

Hedgehog (*Erinaceus europæus*).

Edenvale Caves.

In the upper stratum of all the caves were noticed a few lower jaw fragments and other bones belonging to the Hedgehog. Some were apparently quite recent (E. a. 11); others had an ancient look about them, and were probably derived from the second stratum (E. a. 59).

The Hedgehog has been recorded before from Ireland, but erroneously, the tibia from Ballinamintra Cave, in the Dublin Museum, being that of a Rat. This is therefore the first time that Hedgehog remains have occurred in any cave in the British Islands.

Newhall and Barntick Caves.

Hedgehog remains occurred in no less then 22 bags, of which 21 were obtained from the upper stratum. The majority of the remains consisted of lower jaws, and some of them looked ancient.

Small Horse-shoe Bat (*Rhinolophus hipposideros*).

In all the Edenvale Caves, the Small Horse-shoe Bat is found at the present day; and it was to be expected that its remains would naturally occur in quantity in the upper stratum. As a matter of fact, it was met with in 14 bags of material, most of which were filled from the surface layer. The surface layer, however, consists largely of older remains; and some (E. c. 77) are blackened, and show every sign of being very ancient.

The Bat occurs in the upper and lower strata of the Catacombs, and the Alice and Gwendoline Caves.

Daubenton's *Bat* (*Vespertilio Daubentoni*).

This species was not noticed alive in any of the caves; probably it only spends the winter months there. Its remains are extremely rare in the Edenvale Caves, having been found only in 3 bags out of 538 which were sent to the Museum from this district. Two of the bags came from the Catacombs, and one from the Alice and Gwendoline Caves. All were obtained from the upper stratum, and looked fresh.

Only a single fresh-looking femur was discovered in the Newhall Caves; but those very fragile and delicate bones are easily broken to unrecognisable fragments or overlooked; and we ought not to base any conclusions on these cave remains as to the age of Daubenton's Bat in Ireland.

5. BIRDS.

By E. T. Newton, F.R.S.

The avian remains obtained by Mr. R. J. Ussher from the Alice and Gwendoline Caves, as well as those from the Catacomb Cave, have been submitted to me for identification by Dr. Scharff, together with another series, also collected by Mr. Ussher, from Newhall and Barntick Caves. These remains include a large number of bones belonging to domestic Fowls, Ducks, Geese, and Turkeys, which give a very modern aspect to the collection. Most of these domestic birds, however, occur in the upper stratum of each cave; and it is probable that those found in the lower layers have been carried down by the Foxes and Badgers which, Mr Ussher tells me, have much disturbed the earth by their burrows. The wild birds, whose remains likewise occur chiefly in the upper layers, can nearly all be identified with living species which, with few exceptions, are now inhabiting the neighbourhood.

Mr. R. J. Ussher will give some account of the present distribution of certain of the species represented in these caves; but there are a few

points concerning the identification of the remains which may be mentioned here. The difficulty of determining isolated bones of Passerine and other birds has been alluded to in the first Report referred to (see vol. xxxii., p. 184), and need not be repeated.

Passerine Birds.—Bones of Song Thrush, Blackbird, and Starling are very numerous in some of the caves. The Rook or Crow—I am unable to say which—is fairly well represented in the surface-layer in all these caves.

Hawfinch.—A very massive lower beak of a Finch, wanting the hinder portions of both rami, may, perhaps, be part of a large Hawfinch (Plate IV., fig. 6); but it is so much bigger than the largest example I have seen among the skeletons in the British Museum, that it cannot with certainty be referred to the common species, *Coccothraustes vulgaris*. The width of this cave specimen at the back of the symphysis is 18 mill.; and the length of the symphysis itself to the point of the beak is 15·2 mill. The corresponding measurements of the large Hawfinch in the British Museum are 15 mill. and 13 mill. Dr. P. L. Sclater kindly suggested the possibility of our specimen belonging to the large Finch found in the island of Bonin Sima in the Japanese Sea (*Chaunoproctus ferreirostris*), and there are two examples of this rare bird in the British Museum, the powerful beaks of which certainly seem to correspond better with our specimen; but, as the horny beaks still cover the bone, no satisfactory comparison could be made. The measurements of the beaks of these Japanese birds, corresponding with those given above, but outside the horny coverings, are 20 mill. by 20 mill. respectively. Another large Finch closely allied to the Hawfinch is the *Coccothraustes* (*Eophona*) *personata* from East Siberia and Japan; but the beak of this species corresponds very closely in size with that of our own Hawfinch. The material available for comparison does not justify more than a provisional reference of this cave specimen to the Hawfinch.

Woodpecker.—There are two small femora from two distinct caves, somewhat peculiar in shape, which agree so closely in form and size with that bone in the Great Spotted Woodpecker (*Dendrocopus major*, L.) that I feel justified in adding this species to the list.

Heron.—The Heron is represented in the Newhall Cave by five bones, and in the Catacomb Cave by one piece of a beak.

Geese.—The bones of Geese are numerous, and for the most part larger than those of wild species; probably they are parts of domestic birds. There are, however, a few smaller specimens which seem to represent a wild species; and this may perhaps be the White-fronted Goose.

Ducks.—The remains of Ducks are very numerous, and most of them are referable to the Mallard (*Anas boscas*); they occur in all the caves, and chiefly in the upper strata; other similar bones, but rather larger, are believed to be parts of domestic Ducks, and have been found in all the caves, almost wholly in the upper layers. Several bones are to be referred to the Tufted Duck, and to the Pochard, while a few represent the Widgeon, the Teal, and perhaps the Pintail Duck.

Fowls.—Domestic Fowls of large and small size are represented in all the caves and in all the layers, but are particularly abundant in Newhall Cave.

Pigeons.—The Wood Pigeon was present in three out of the four localities; and a smaller form, which may have been a domestic Pigeon, was found in two places.

Crane.—Among the avian remains from these caves, those of the Crane will, perhaps, have the greatest interest for ornithologists, and concerning these Mr. Ussher makes some interesting remarks (see p. 60). There are seven bones from the Catacomb Cave which are referable to the Common Crane (*Grus communis*), five from the lower stratum, and two from the superficial layer (Plate IV., figs. 1, 2, 3, 5); probably these are all parts of one bird, and most likely belonged to the lower stratum. Two of these bones are a right and a left coracoid, one nearly perfect; two are portions probably of one radius, showing proximal and distal extremities; and three are cervical vertebræ, one the short third bone from the head, and two are elongated and consecutive bones, apparently the seventh and eighth of the series. A comparison of these bones with the skeleton of a Common Crane in the Museum of the Royal College of Surgeons satisfied me as to the identity of the species, all the cave bones, however, being a little larger than those of the recent skeleton. It has been thought desirable to have these remains of the Crane illustrated; and attention is called to the peculiarities of the coracoid (fig. 5), the obliquity of its sternal articulation,

the deep notch made by the inner process towards the upper end, the large foramen just below this notch, and strong muscle-ridge which extends along the whole length of the front of the bone towards its outer edge.

A portion of a large femur from the Newhall Cave is likewise referred to the Common Crane (Plate IV., fig 4); but its characters are not so definite as those of the coracoids from the Catacomb Cave.

Table of the Remains of Birds.

(*The figures show the number of bones of each species obtained.*)

Name of Species.	Alice and Gwendoline Caves.		Catacomb Cave.		Newhall Cave.		Barntick Cave.		Total Number of Specimens.	Total Percentage.	
	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.		Upper Stratum.	Lower Stratum.
Missel Thrush, *Turdus viscivorus*, L., ...	4	—	3	3	—	—	—	—	10	70	30
Song Thrush, *Turdus musicus*, L., ...	34	4	5	—	10	2	1	—	56	89·3	10·7
Redwing, *Turdus iliacus*, L., ...	5	1	1	—	1	1	1	—	10	80	20
Fieldfare, *Turdus pilaris*, L., ...	1	—	—	—	—	—	—	—	1	100	—
Blackbird, *Turdus merula*, L., ...	28	7	24	12	14	1	—	—	86	76·74	23·26
Robin, *Erithacus rubecula*, L., ...	15	1	1	1	2	—	—	—	20	90	10
Wagtail ? *Motacilla* ?, ...	4	—	—	1	—	—	—	—	5	80	20
Martin (House), *Chelidon urbica*, L., ...	—	—	—	—	1	—	—	—	1	100	—
House-Sparrow, *Passer domesticus*, L., ...	1	—	—	—	—	—	—	—	1	100	—
Hawfinch ?, *Coccothraustes vulgaris*, Pall. ?, ..	—	—	—	—	1	—	—	—	1	100	—
Bullfinch, *Pyrrhula europæa*, Vieill., ...	—	—	1	—	1	—	—	—	2	100	—
Yellowhammer, *Emberiza citrinella*, L., ...	—	—	—	—	6	—	—	—	6	100	—
Starling, *Sturnus vulgaris*, L., ...	113	8	6	1	13	—	1	—	142	93·66	6·34
Jay, *Garrulus glandarius*, L., ...	—	—	4	—	2	—	—	—	6	100	—
Magpie, *Pica rustica*, Scop., ...	1	—	1	—	3	—	—	—	5	100	—
Jackdaw, *Corvus monedula*, L., ...	—	—	8	1	9	—	—	—	18	94·44	5·56
Crow or Rook, *Corvus* sp., ...	7	3	21	2	96	4	6	—	139	93·5	6·5
Raven, *Corvus corax*, L., ...	1	—	5	—	11	2	1	—	20	90	10
Great Spotted Woodpecker, *Dendrocopus major*, L., ..	1	—	—	—	1	—	—	—	2	100	—
Barn Owl, *Strix flammea*, L., ...	—	—	3	—	—	—	—	—	3	100	—
Sparrow-Hawk, *Accipiter nisus*, L., ...	—	—	—	—	8	—	—	—	8	100	—
Cormorant, *Phalacrocorax carbo*, L., ...	—	—	—	—	1	—	—	—	1	100	—
Heron, *Ardea cinerea*, L., ...	—	—	1	—	5	—	—	—	6	100	—
Domestic Goose, *Anser* sp., ...	—	2	20	2	89	5	5	—	123	92·68	7·32
White-fronted Goose ?, *Anser albifrons*, Scop. ?, ..	1	2	1	1	62	3	—	—	70	91·43	8·57
Wild Swan, *Cygnus* sp., ...	—	—	2	—	—	—	—	—	2	100	—
Sheld-duck, *Tadorna cornuta*, S. G. Gmel., ..	—	—	—	—	1	—	1	—	2	100	—
Mallard, *Anas boscas*, L., ...	21	8	22	6	221	18	10	1	307	89·25	10·75
Domestic Duck, *Anas* sp., ...	5	—	12	—	13	2	2	—	34	94·1	5·9
Pintail Duck ?, *Dafila acuta* ?, L., ...	—	—	—	—	7	—	—	—	7	100	—
Wigeon, *Mareca penelope*, L., ...	1	—	1	1	9	—	—	—	12	91·66	8·34
Teal, *Querquedula crecca*, L., ...	—	—	—	—	5	—	—	—	5	100	—
Pochard, *Fuligula ferina*, L., ...	—	—	2	—	15	—	—	—	17	100	—
Tufted-duck, *Fuligula cristata*, Leach, ...	12	—	8	1 ?	7	—	—	—	28	96·4	3·6
Wood-pigeon, *Columba palumbus*, L., ...	2	—	5	2	15	—	—	—	24	91·66	8·34
Domestic Pigeon, *Columba* sp., ...	—	—	2	1	1	—	—	—	4	75	25
Red Grouse, *Lagopus scoticus*, Lath., ...	—	2	—	—	—	—	—	—	2	—	100
Pheasant ?, *Phasianus colchicus* ?, L., ...	2	—	21	7	14	4	2	—	50	78	22
Partridge, *Perdix cinerea*, Lath., ...	—	—	7	—	1	—	—	—	8	100	—
Quail ?, *Coturnix* ?, ...	—	—	—	—	1	—	—	—	1	100	—
Fowl, large and small (*Gallus domesticus*), L., ..	9	1	61	17	329	15	21	1	454	92·51	7·49
Turkey, *Meleagris gallopavo*, L., ...	—	—	24	—	9	—	—	—	33	100	—
Land-Rail, *Crex pratensis*, L., ...	—	—	—	—	7	—	12	—	19	100	—
Water-Rail, *Rallus aquaticus*, L., ...	1	—	2	1	1	—	2	—	7	85·71	14·29
Moor-hen, *Gallinula chloropus*, L., ...	—	—	1	—	—	1	—	—	2	100	—
Coot, *Fulica atra*, L., ...	—	—	3	—	—	—	—	—	3	100	—
Crane, *Grus communis*, Bechst., ...	—	—	2	5	1	—	—	—	8	37·5	62·5
Golden Plover ?, *Charadrius fulvus* ? Gmel., ..	1	—	—	—	—	—	—	—	1	100	—
Lapwing, *Vanellus vulgaris*, Bechst., ...	—	—	—	2	21	2	5	—	30	86·66	13·34
Woodcock, *Scolopax rusticula*, L., ...	—	—	—	—	2	—	—	—	2	100	—
Common Snipe, *Gallinago cælestis*, Frenzel, ..	—	—	1	1	—	2	—	—	4	25	75
Redshank, *Totanus calidris*, L., ...	—	1	—	—	—	—	—	—	1	—	100
Razorbill, *Alca torda*, L., ...	—	—	—	—	1	—	—	—	1	100	—
Guillemot, *Uria troile*, L., ...	—	—	1	—	—	—	—	—	1	100	—
Red-throated Diver ?, *Colymbus septentrionalis* ?, L., ..	—	—	—	—	4	—	—	—	4	100	—
Great Northern Diver, *Colymbus glacialis*, L., ..	—	—	2	—	—	—	—	—	2	100	—
Great Crested Grebe, *Podiceps cristatus*, L., ..	—	—	7	1	21	2	2	—	33	90·9	9·1
Little Grebe, *Podiceps fluviatilis*, Tunstall, ..	—	—	4	—	1	—	—	—	5	100	—
Geese (undetermined), ...	—	—	—	—	—	—	—	—	11	—	—
Ducks (undetermined), ...	—	—	—	—	—	—	—	—	69	—	—
Thrush ?, ...	—	—	—	—	—	—	—	—	12	—	—
Birds (undetermined), ...	—	—	—	—	—	—	—	—	94	—	—
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6. REMARKS ON THE BIRDS.

By R. J. Ussher, D.L.

We are again indebted to the kindness of Mr. E. T. Newton, who has applied his skilled attention in determining, by comparison with his collection and with those in Museums, more than 2,000 bones found in the Caves of Edenvale and Newhall.

These he assigns to fifty-eight species, most of which inhabit the district at the present day, and certain common species such as Blackbird, Starling, Rook, and Mallard are largely represented by the specimens.

The presence of birds' bones in caves may be chiefly attributed to Rats and Foxes which bring them in, while Starlings and other small birds retreat for shelter during frost and snow, and die there.

The Catacombs at Edenvale were in the vicinity of the mansion-house, and were frequented by Rats which doubtless brought into the caves the bones of Ducks, Fowl, Turkeys, and Partridges found in the refuse; while the Newhall and Barntick Caves, which were more resorted to by Foxes and Badgers, and were close to lakes and marshy ground, yielded not only bones of Geese and Fowl in hundreds, but also remains of Rooks, White-fronted Geese, Wood-Pigeons, and Land-Rails, besides several species of Ducks:—Sheld Duck, Mallard, Pintail(?), Wigeon, Teal, Pochard, and Tufted Duck. Of these the Sheld Duck breeds, at the present day, in the crag close to the Newhall Caves, though this is some distance from the estuary of the Fergus; and the other Ducks (the Mallard excepted) are winter visitors. Pheasants are preserved both at Edenvale and Newhall, so that the presence of their bones is to be expected.

The disposal of the bird remains in the different strata has been largely affected by the burrowing animals above mentioned, which dug through them all; so that, where we find an existing bird in the second stratum, it is impossible to say that it may not have been dragged in by a Rat or Fox. Still it is noticeable that the vast majority of the bird bones were found in the upper stratum; this may have been due, in the case

of small birds, to their delicate and perishable nature as compared with the bones of Mammalia; so that many ancient bird bones may have perished, which might otherwise have been found in the second stratum.

Passing over the five common species of the Thrush family, and a few other small birds, the first unexpected species announced by Mr. Newton is a Hawfinch-like bird. If this were the common Hawfinch, it is interesting, as this is now a scarce and irregular winter visitor, best known in Ireland by its occurrences near Dublin; but it is stated to have bred in County Kildare.

The Jay has six specimens assigned to it by Mr. Newton, who says that he is tolerably certain about these. The Jay seems to be unknown at the present day in the County Clare, as it is in County Sligo, though its remains occurred there in the Plunkett Cave.

There are twenty bones of Raven, a species now rare in the district, though found on the west coast of the county, where it still breeds sparingly.

A femur of Great Spotted Woodpecker from Edenvale, and another from Newhall, are unexpected finds. Though this bird occurs more frequently in Ireland than any other Woodpecker, it is now a rare and accidental visitor; its relics in these caves may indicate that it was a denizen of the Irish forests which have perished.

Three bones of Barn Owl may have come from the "game-keeper's museum" on a neighbouring tree; but it is more difficult to account for eight bones of Sparrow Hawk from the Newhall Caves, in a lonely spot; and we would imagine this a bird less liable to be taken by Foxes even than the Woodcock, of which we have two bones from the same caves.

Two wing-bones of Swan appear to Mr. Newton to be too small for Mute Swan; but it should be observed that these did not occur in the Newhall Caves, in the vicinity of the larger lakes, but at Edenvale, where Mute Swans are kept.

A bone of Red Grouse from the lower stratum indicates another bird not now found in that part of County Clare.

One would hardly expect the Water-Rail, yet there are seven bones of it as against two of Moor-hen, and three of Coot.

That the remains of Crane should occur in the lower stratum, to which they appear to belong, is a most interesting fact; and it tends to confirm the accuracy of Giraldus Cambrensis, who stated that, in the twelfth century, Cranes were to be met with in Ireland in flocks of about a hundred individuals.

Golden Plover from the Alice Cave at Edenvale is rather unexpected; but Lapwings, Snipes, and Redshanks breed in marshy spots about Ballybeg Lake, near Newhall, and Grebes doubtless inhabited Edenvale Lake. All these birds are represented in Mr. Newton's lists.

Four sea-birds, the Razorbill, Guillemot, Great Northern and Red-throated Divers, are more difficult to be accounted for, as they do not (like the Cormorant) resort to fresh-water lakes, though in violent storms stragglers are sometimes blown inland.

7. HUMAN REMAINS.

By Prof. A. Francis Dixon, Sc. D.

The Catacombs.

The human bones collected in this cave show clearly that much disturbance had taken place before they were removed; and in some cases portions of the same bone have been procured from widely separated situations. For instance, two portions of the same lower jaw are numbered 82 and 240; a fragment of the left side of the facial portion of a skull bears the number 240, while the right side is marked 82; two portions of the same femur are marked 239 and 79; and fragments of the same ulna are marked 32 and 236. All the human bones found were obtained in the upper stratum.

The bones collected represent parts of the skeletons of at least three adult persons and one child. The various portions of the skeletons are much broken; and the great majority of the fractures seem to have occurred quite recently, probably, for the most part, during the process of removal. Only one or two specimens show signs indicating that they may

have been broken before burial, or at some time before the animal matter was removed.

The bones appear to have belonged to normal and well-developed individuals, but unfortunately none of the long bones are sufficiently well-preserved to give an accurate idea of the stature of the persons to whom they belonged. No indications of disease are present.

The greater part of a cranium and the jaws of a well-developed man are amongst the remains preserved. In this skull the various parts of the cranial vault are normally developed; and the frontal sinuses are large, but not excessive. All the teeth, especially the molars, are much worn down; and in the latter the pulp is apparently calcified. There is no evidence of dental caries. The skull is slightly dolicho-cephalic, its cephalic index being 746; its greatest length is 193 mill.; and its maximum breadth is 144 mill. The height of the cranium (basi-bregmatic) is 136 mill., which gives an altitudinal index of 705; the skull is therefore tapeino-cephalic. The auricular height is 121 mill.; and using the formula* proposed by Dr. Alice Lee we may estimate the cranial capacity of the skull as 1526 cubic centimetres.

The right and left jaw-bones of another skull are preserved, in which the right canine and all the premolars and molars are in place. The molars are much worn down, and present a striking appearance—their labial margins forming sharp-cutting edges. This is due to the fact that the lingual edges and crowns of the teeth have suffered most in the attrition. The inner root of the first molar on each side lies free of the bone close to the inner wall of the alveolus; and it would appear that its inner surface was exposed within the mouth-cavity during life, for it is smooth and much worn. The condition of the teeth is quite symmetrical, and must have been associated with a peculiar conformation of the dental arch of the lower jaw. A somewhat similar condition of the teeth is to be seen in the skull of an Australian, No. 154, in the Museum, Trinity College, Dublin, in which, however, the peculiarity is not developed to so marked a degree.

* The formula, which is based upon a study of the results obtained for a series of male German crania, is, $C = 7{\cdot}348\,L + 10{\cdot}898\,B + 5{\cdot}228\,H - 2094{\cdot}31$.—Phil Trans., vol. 96 A. 1901.

Among the other human remains from this cave are portions of the following bones of the lower extremity:—Two femora, three tibiæ, four fibulæ, an astragalus, an os calcis, and a number of incomplete metatarsal bones.

The following bones of the upper extremity are present:—Fragments representing two scapulæ, portions of two clavicles, a portion of a humerus, three incomplete radii, two incomplete ulnæ, a number of metacarpal bones, and some phalanges.

A number of vertebræ, most of which are broken, and which represent portions of the spinal column of at least two individuals, the vertebral ends of five ribs, a complete first rib, and a manubrium sterni are present.

In addition to these, all of which are from adult individuals, a young clavicle, and a portion of the left humerus of a child, were obtained in the cave.

There is little to be said with regard to the specimens in the above list. The two femora probably belonged to the same individual; in both the upper part of the shaft exhibits a platymeric condition, and a third trochanter is present. Unfortunately the lower extremity of each is absent, and so the length of the bone cannot be determined.

The astragalus shows a well-marked pressure facet on the outer part of the upper surface of the neck.

One of the incomplete ulnæ appears as if it had been gnawed by some small animal; marks such as those which would be caused by teeth of a Rat are plainly visible, especially of the interosseous border of the bone. The line of fracture in this bone, and also in a radius which may have formed a part of the same forearm, is not recent, but probably occurred before the bones were buried. Among the metacarpal bones are a right and left index metacarpal, possibly from the same individual; these are remarkable for their length, and measure 75 and 73 mill. They appear to have been part of the skeleton of a tall man.

The portion of the young humerus shows a striking prominence on the upper part of the outer supra-condylar ridge.

Alice and Gwendoline Caves.

The human remains in these caves are portions of a young adult individual, and there is nothing to show that more than one skeleton is

represented. Carpal and metacarpal bones, together with phalanges of the hand and foot, form the greater number of the specimens preserved. Some broken vertebræ and small portions of the following bones are also present —sacrum, clavicle, humerus, ulna, cuboid, and twelfth rib. An incisor tooth was the only portion of a skull obtained.

Newhall Caves.

Among the human bones marked N. H. 1 to 150, and belonging therefore to the first stratum, there are portions of at least three, and probably of a greater number of, different skeletons. The bones all belong to well-developed adult individuals, one of whom at least was a tall, powerful man, probably about five feet ten inches in height. A large and strong clavicle, and several large hand- and foot-bones, which may well have belonged to the same individual, bear testimony to the strength and powerful development of the man they represent. The clavicle measures 147 mill., and the average of thirty specimens taken at random from subjects dissected in Dublin is found to be 142 mill. Among these thirty clavicles, nine specimens were 147 mill. or longer. A metatarsal bone of the great toe measures 70 mill., and is thick and massive in proportion to its length. Thirty specimens of this bone collected at random in Dublin give an average length of 60·5 mill., and none happens to be as much as 70 mill. in length, although bones of such length are occasionally found here. An index metacarpal bone measures 78 mill., and another 74 mill.; the average of thirty specimens collected in Dublin is 66·5 mill. Of this thirty, the longest measures 76 mill., and no other exceeds 73 mill. in length.

A portion of a lower jaw is preserved; and it is remarkable in possessing a very wide ascending ramus, which measures 40 mill. across. The average given by Cunningham for Irish specimens is 33 mill. The condylar height is not proportionately great, as it is only 71 mill., the average given by Cunningham being 70 mill. The three molar teeth present, although much worn, are not nearly so much ground away as

they are often found to be in skulls from ancient Irish burial-places. This specimen is possibly somewhat artificially distorted.

A fragment of the lower end of a humerus shows a foramen above the trochlea.

Most of the long bones preserved are in a fragmentary condition; but a humerus 30 cm. in length, and a right and a left ulna, are almost complete. These belonged to individuals who were probably about 5 feet 3 inches in height. A fragment of a much larger humerus, and of a larger ulna, are also present, but these are too imperfect to give any accurate idea of the stature of the individual, or individuals, to whom they belonged.

A portion of the lower end of a tibia shows on the anterior edge of its lower end a pressure facet for the upper and outer part of the neck of the astragalus; and, in three specimens of astragalus which are preserved, pressure facets are present on the outer part of the upper surface of the neck. These are of interest because it is well known that such facets occur normally in individuals, of different races, who habitually adopt a squatting attitude when resting.

A curious curving which is exhibited by some of the metacarpal bones has probably resulted from a special occupation pursued by the individual to whom they belonged.

Evidence of disease is to be found in four dorsal vertebræ, which are ankylosed, probably as a result of rheumatic trouble, and in an astragalus which presents signs of an old fracture, and of rheumatic inflammation of the surrounding joints.

The human remains from the lower stratum are represented by a metatarsal bone and a fragment of an adult radius. These are not sufficient to give any information regarding the individual or individuals to whom they belonged.

Barntick Cave.

First Stratum.—The human remains are represented by a small fragment of a right fibula, a small portion of the roof of a cranium, and a fragment from the region of the symphysis of the lower jaw. The latter specimen exhibits a normal mental protuberance.

Table showing the Distribution of the Human and Animal Remains in the Clare Caves.

(*Exclusive of Invertebrates and Birds.*)

Species.	Alice and Gwendoline Caves.		Catacombs.		Newhall Caves.		Barntick Caves.	
	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.	Upper Stratum.	Lower Stratum.
Fish remains, ...	×	—	×	—	×	—	×	—
Frog (*Rana temporaria*), ...	×	×	×	×	×	×	×	×
Domestic Pig (*Sus scrofa domesticus*), ...	×	?	×	?	×	?	×	?
Wild Pig (*Sus scrofa ferus*), ...	×	×	×	×	×	?	×	?
Red Deer (*Cervus elaphus*), ...	×	×	×	×	×	×	×	×
Irish Elk (*Cervus giganteus*), ...	×	×	×	×	×	×	—	—
Reindeer (*Rangifer tarandus*), ...	×	×	×	×	×	×	—	—
Goat (*Capra ægagrus*), ...	×	—	×	×	×	×	×	—
Sheep (*Ovis aries*), ...	×	×	×	×	×	×	×	×
Ox (*Bos taurus*), ...	×	×	×	×	×	×	×	—
Horse (*Equus caballus*), ...	×	—	×	×	×	×	×	×
Arctic Lemming (*Dicrostonyx torquatus*), ..	×	×	×	×	×	—	—	—
Field Mouse (*Mus sylvaticus*), ...	×	×	×	×	×	×	×	—
Irish Rat (*Mus decumanus hibernicus*), ...	×	—	×	×	×	×	—	—
Black Rat (*Mus rattus*), ...	—	—	—	—	×	—	—	—
Irish Hare (*Lepus timidus* = *L. variabilis*), ..	×	×	×	×	×	×	×	×
Rabbit (*Lepus cuniculus*), ...	×	×	×	×	×	×	×	×
Irish Stoat (*Putorius ermineus hibernicus*), ..	×	—	×	—	×	—	—	—
Marten (*Mustela martes*), ...	×	—	×	×	×	×	×	—
Otter (*Lutra lutra*), ...	—	—	—	—	×	×	—	—
Badger (*Meles taxus*), ...	×	×	×	×	×	×	×	×
Bear (*Ursus arctos*), ...	×	×	×	×	×	×	—	—
Dog (*Canis familiaris*), ...	×	×	×	?	×	×	×	—
Wolf (*Canis lupus*), ...	?	?	?	?	?	?	×	—
Common Fox (*Vulpes alopex*), ...	×	×	×	×	×	×	×	×
Arctic Fox (*Vulpes lagopus*), ...	—	—	—	—	×	—	—	—
Domestic Cat (*Felis domestica*), ...	×	—	×	×	×	×	×	?
African Wild Cat (*Felis ocreata* = *F. maniculata*, &c.),	×	—	×	—	×	?	?	?
Shrew Mouse (*Sorex minutus*), ...	—	—	×	—	—	—	—	—
Hedgehog (*Erinaceus europæus*), ...	×	—	×	—	×	×	×	—
Small Horse-shoe Bat (*Rhinolophus hipposideros*),	×	×	×	×	—	—	—	—
Daubenton's Bat (*Vespertilio Daubentoni*), ..	×	—	×	—	×	—	—	—
Man, ...	×	×	×	×	×	×	×	—

8. HUMAN OCCUPATION, WITH HISTORICAL NOTES.

By T. J. Westropp, M.A.

The district of crags and lakes in which the caves of Edenvale, Barntick, and Newhall occur seems unnoticed in any very ancient records. It appears to have formed part of an early settlement of the Ui Cathbar and Ui Corra; eventually the Ui Cormaic spread over the "Triucha Caed" of the islands. The Augustinian Convent of St. John of Killowen was built in Newhall by Donald Mór O'Brien, last King of Munster, about 1180; and the lands are also named in his charter to Forgy Abbey in 1188. Either the Edenvale or the Rockmount ridge figures under the name "Drom Grencha," as the lurking-place of the Clan Torlough, before their surprise of the army of Mahon O'Brien, near Clare Abbey, in 1278. It was then a wooded and watery place, and evidently uninhabited. In the later fifteenth century a castle was built on Killone, midway between the caves of Edenvale and Newhall; this is now included in Edenvale, which was formed, since 1652, out of portions of Killone, Kilmorane, and Cahercalla. The tradition of the clearing of part of the "Catacombs," by Mr. George W. Stacpoole, early in the last century, has been already noticed by Mr. Ussher.

In dealing with the actual remains of human workmanship found at Edenvale, Barntick, and Newhall, we are met by certain difficulties, both as to their age and the import of their occurrence in the caves. We therefore prefer to deal with the contents of each cave as far as possible independently, collecting together objects of the same material. Decision as to age must follow from the study of these antiquities rather than from the depth or position of their occurrence in the earth, which has been disturbed in many places. As to the question of human occupation and its duration, but little can at present be said. The Alice and Gwendoline Caves (or, as they were known before the excavations, the Bull-paddock Cave) yielded abundance of charcoal and bones of Mammals

and of a Cod, but the chief "finds" were of doubtful import. The gold bracelet was manifestly buried for concealment; the "wire" bracelet dropped with the bones and other debris of the midden down the up-shaft of the cave from some settlement on the crags overhead. Bones of Bear, Elk, and Lemming occurred in the upper stratum with much charcoal. The Catacombs Cave was rich in human remains and charcoal. In it were found flint and chert scrapers and flakes, a bone whorl, an inlaid clasp, perhaps of the tenth century, and two skians or daggers, some centuries later in date. In the Newhall Caves bronze pins occurred, and an interesting round stone lamp was unearthed. Altogether, it is evident that these caves, especially the Catacombs and the caves on the "Pilgrims' Road" in Newhall, bear traces of human occupation of some continuance in early times. The bracelets, daggers, and clasps give no evidence of the cave having given more than shelter, or at most a brief residence, to an occasional individual, with long intervals of time between such tenancies. Of course we must be cautious as to assertion of very early habitation, founded on the mere occurrence of stone implements. "Finds" containings such remains, and mixed with iron and other objects of a late and historic period, teach us the necessity of only building on wider bases, and these again are largely dependent on the fact that the site of the discoveries are, as nearly as possible, undisturbed. The later retention of such early objects as flint arrow-heads for amulets and charms is also well established. The occurrence of the Bear in historic times in Ireland is also a difficult question; but we recall (with all reserve) that Rath Lake, hardly eight miles from Edenvale, is, in the early mediæval Life of St. Maccrecius, or Maccrehy (living about A.D. 540–580), the scene of the raids of an enormous and ferocious "Badger," which devastates the country from its cave above the lake (still called "Poul na bruckee," or "Badger's hole"), slaying men and cattle.

The Alice and Gwendoline Caves.

These being only portions of the Bull-paddock Cave need not be separated in our inquiry. The Alice Cave contained charcoal in

stalagmite, and was littered with large stones, possibly the debris of defensive walls built across the passages. The remains of an apparently early "blocking wall" were found in the side tunnel at 40 feet from the main entrance. The gold bracelet was found in a recess at the entrance of the passage leading to the up-shaft into which had been thrown the stones gathered out of the large hall. At the inner end of the Alice Cave an up-shaft led to the plateau overhead. This had been used for a midden, and was full of bones of domestic animals, among which were found a fish-bone and the bronze "wire bracelet." There were many large lumps of charcoal among the debris of this midden. We may here note that the charcoal in the Edenvale Caves shows signs both of wood and of peat, and sometimes contains charred bones both of men and animals.

Bone Implements occurred in the shape of pins. A bone awl or piercer was found in the cave by Miss Neville. One had a finely-worked point, another was highly polished, and the third had a well-cut head (E. A. 173, 52, 60); two others were also found (21, 26). Besides these pins, there were dug up a core bone of an antler of the Red Deer, with several incisions (131), and a tooth ground at the root (157).

Amber.—A single flat oval bead of this substance was found about a yard from the gold bracelet in the large chamber of the Alice Cave.

Stone.—Besides several of the little sharpening-stones of shale (so generally found in these caves, and in use at all periods), a stone scraper (E. A. 6), and one of chert (17), with several burned stones, were found in the Alice Cave. Another part of the cave yielded a quartzite stone and a quartz pebble (30).

Metal.—The Alice Cave also yielded two of the most valuable objects found in the excavations. Not far from the amber bead, near the right-hand wall of the main chamber, a golden bracelet was found in the upper stratum of brown earth. The bracelet had evidently been concealed, for it lay at no great depth between small stones, with a small slab laid overhead. It weighed 2 oz. 0 dwt. 19 gr., and consisted of a simple slip of flat gold $6\frac{3}{4}$ in. long, and $\frac{3}{8}$ in. wide, $\frac{1}{8}$ in. thick, bent round till the squared ends met (Plate v., fig. 16). The loop so formed is an oval $2\frac{1}{8}$ in. by $1\frac{7}{8}$ in. It has no attempt at ornamentation.

Another bracelet (E. A. 177), as already noted, was found in the debris of the kitchen-midden at the inner end of the Alice Cave. It is of bronze, a thin band relieved by X crosses, lozenges, and chevrons of a pattern in use not long before the commencement of our era. The ends taper to wires and overlap; the wires are twisted into spiral loops, each end round the other band of the strip. The loops passed freely along the thicker bands, so as to allow the bracelet-loop to be enlarged till a hand could pass through it, tightening again when on the wrist. It forms a ring 2 in. in diameter. A coin of James II. was found in a crevice just outside of the entrance of the Alice Cave, and to the right. Worked iron and large iron nails (6, 18) were found in the main grotto; and another nail in the tunnel to the right (24). A leaden bullet, and modern traps, probably brought into the cave by wounded animals, were also found.

The Catacombs.

Below the modern house of Edenvale, the mouth of a large cave opens upon the car-track, which leads down the cliff and sloping talus to the lake and the glen. It was known to have several ranges of galleries to either side of the main passage; its actual complexity was, however, more fully disclosed by the excavations, and earned it the appropriate name of the Catacombs. We now record the "finds" in this cave, barely recalling that the Kid Gallery and Westropp Gallery lie to the north; the Cross Gallery and Broadway are on the south, and coalesce into the Smoke Gallery; the Surprise Gallery (roughly parallel to the entrance passage) opens from the Great Hall, and receives the White Cake Gallery, a branch once divided for all its length from the Cross Gallery, its continuation to the south being the Unfortunate Man's Gallery, parallel to which, but of much greater length, is the Dog's Gallery, which either joins the Smoke Gallery, or has a cross-passage into the latter.

Sea Shells.—These satisfactory proofs of human presence are not absent from the Catacombs. Of course the question of their age is very doubtful, but they are possibly of some antiquity. Specimens were found in the

Catacombs; the limpet occurred in the Dog's Cave and Smoke Gallery, and a pierced littorina in the Surprise Gallery (E. C. 344 and 73). The perforation had been facilitated by rubbing away part of the surface in a shell found in the Elder-Bush Cave at Newhall.

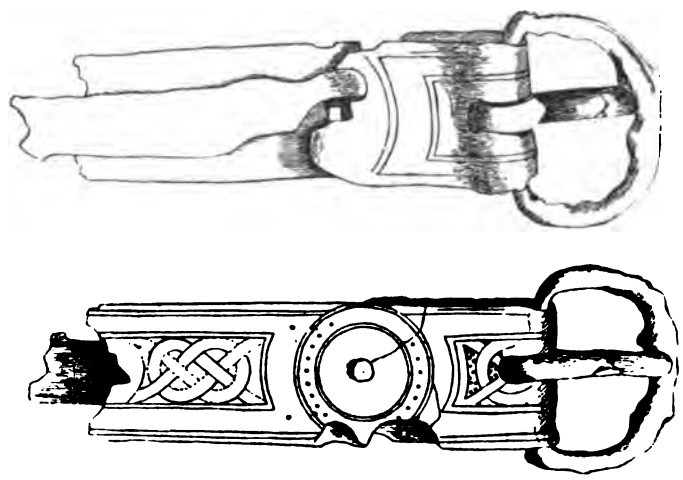
Bone Objects.—Of these, a bone scraper (50), a shaped bone in the Surprise Gallery (93), and a human bone showing cuts (134) in the Cross Gallery to the left, were found. The Westropp Gallery yielded the end of an Ox femur cut off and carefully pierced (304), perhaps for a spindle-whorl; and the Dog's Gallery, a shaped bone and the polished tooth of a pig (321, 339). Splintered bones, with no trace of shaping, also occur; and a tooth pierced at the root, with the top greatly polished (93, 55). A femur of the Irish Elk was also found with the ends broken off it. In the White Cake Gallery was a bone scraper with one end brought to a blunt point; the bone was light and porous and evidently of great age (239). A very beautiful bone pin was also discovered in the Entrance Gallery; it was finely polished and very white (52). Another long splintered bone had evidently been rudely formed, probably to be a pin (61). A pierced Boar's tusk found in this cave was probably worn on a thong as a weapon or an ornament.

Stone Objects.—The Catacombs were not devoid of stone antiquities. A shell-shaped white chert scraper (50) was found near the entrance; and, not far away, a second and larger one (54). A scraper of white flint nearly $1\frac{1}{2}$ in. long, and still retaining a good edge, was found in the Surprise Gallery (89). In the first cross-gallery to the left, near the entrance of the East Gallery, were several splinters of shale and stone of doubtful object, and perhaps not implements. One piece of shale (179) was rudely shaped and rubbed on one side, so as to give it a wedge-shaped section. A polished stone and pebble were found in the Westropp Gallery (304).

Metal.—Near the entrance, which had not only been opened about 1810, but had been the receptacle of rubbish from the roadway, was found an iron horse-shoe and nails. There were, however, far older traces of metal work in this fine range of caves. In the first gallery to the right of the main entrance were found remains of metal mountings. These were a bronze strap, a buckle or brooch of bronze, plated in silver, and engraved

with an interlaced pattern, and a third piece of bronze bent back on itself and riveted to form an "eye,"* probably belonging to the same ornament. In the Surprise Gallery, near the entrance, were two skians or knives of considerable antiquity (74, 86). The first was an iron blade with a short "tang," $3\frac{3}{4}$ in. in all, and $\frac{7}{8}$ in. broad at the shoulder, with a thick back; the second, about 18 in. below the surface of the upper stratum, was about $6\frac{3}{4}$ in. long, with a "tang" 2 in. long and square shoulders an inch broad. It will be remembered that the Surprise Gallery opened on the cliff, and was only closed when the roadway was made down to the glen. An iron chain of no great age was found in the Badgers' Den at the entrance to the Dog's Gallery, possibly part of a trap or of harness.

Scraper (E. C. 54) from the Catacombs, Edenvale.



Bronze and Silver Strap Mounting from the Catacombs, Edenvale.

Various.—Besides charcoal, burned sticks, rubbed stones, and splintered bones, we may note the occurrence of modern china, earthenware, and glass in the entrance gallery. It has been suggested that traces of cannibalism were also found; but the subject is too vague and the evidence too inconclusive and obscure to allow of any definite conclusion. As Mr. Ussher points out, there are no traces of former burial in any of these caves; and the bones of human arms, legs, hands, and feet were usually and widely

* Plate V., fig. 13.

discovered, apart from any trace of other bones. The skull of the "unfortunate man" was cut (or broken) open, and lay under a mass of broken human bones. The lesser bones were scorched, cut, splintered, and found in charcoal under undisturbed tufa. A humerus and an ulna coated with charcoal were dug up, the first in an undisturbed bed of the same substance, and the ends of some of the large bones were actually cut off. The circumstances are at least suspicious, whatever may be the true explanation.

The Bats' Cave.

This cave lies in Newhall, high above the "Pilgrim's Road" to St. John's Well and Killone Abbey. Its mouth was choked with large blocks, among which, in pockets of earth, many objects were discovered. Inside, it was free from blocks, and had a hard floor or bed of charcoal and quartz spar.

Bone Objects.—The perforated canine tooth of a dog was found, and a second which had the point cut off and a groove cut round the end (1). Here also were found a long slender bone pin and charred bones, some of them human, and a "whorl" formed of the head of a femur (73).

Stone Objects.—By far the most remarkable of the stone objects found in this group of caves was an ancient stone lamp, found at 25 feet from the entrance by John Power. It was a stone artificially rounded, not carved in any pattern, but having a boring and flutings below and two deep fine grooves round the sides. It is about $2\frac{7}{8}$ inches high, $5\frac{1}{2}$ inches in diameter, and the hollow is $1\frac{1}{2}$ inch deep, and $3\frac{1}{2}$ inches in diameter. This basin appears to have been first picked and then ground like the little "bullauns" or basins found in slabs at certain dolmens in this county. The upper rim was burned and blackened by the fire, possibly of moss-wicks, while the lower part had been kept clean by the oil or fat (126).

Bronze.—A well-made bronze pin, with a shapely "thistle" head, was found by Miss Diana Parkinson, near the entrance of this cave. There were also two other bronze objects with long slender points (1).

Various.—Sea shells were found near the entrance, also several late objects, such as an iron knife, and a pulley (10, 12). There was also

found a rounded stone "about the size and shape of a pheasant's egg."

Elder-Bush Cave.

At the south-west end of the same ridge as the last is another and more complicated cave. Unlike the last, human remains were very abundant in this cave, and were found with bones of domestic animals and charcoal in "pockets." One humerus had been broken, and was found in a bed of charcoal in the Threatening Gallery. The Elk Gallery forms the main passage, and is at right angles to the cliff, and has three cross-passages.

Bone Objects.—A slender bone pin of beautiful execution was found by Mrs. MacDonnell, in the surface-earth and charcoal, among stones near the entrance (3); at about 35 feet from the entrance, a neatly-carved little spatulate instrument, the stem ending in a sharp point, the shoulders of the flat part cut very evenly (64). At 45 feet from the cave mouth, at the intersection of the main cave with the second cross-gallery, was made a noteworthy discovery. It was the upper half of a canine tooth of a large Bear, which had been cut round irregularly—the lower part having been broken away. This cutting (if contemporary) would give decisive evidence that Men and Bears were once found together in Ireland (98). It must have been before the dawn of existing Irish literature, in which, up to the present, no Bear is found to play any part.

Besides these bones, there were others, sawn and pierced, and a worked rib or bone-flake (129).

Other Objects.—A stone scraper was found, with charred and cut bones, in the Elk Gallery. Marine shells also occurred—one had been rubbed down and perforated. Many modern objects were turned up: broken glass from a lantern, a trap, snares, soda-water covers with loops, a wax candle, and a pen-knife. The last was found in the inner part of the Elk Gallery, which was inaccessible from the lowness of the roof, so we can only conclude that an animal had brought it in, as the place

was often deeply burrowed. Carboniferous fossils lay loose in the earth, and were probably brought in, from curiosity or superstition, by the ancient inhabitants. Fragments of leather were also found.

Barntick or *Cragmore Cave.*

Almost facing the Elder-Bush Cave, but on the opposite side of Ballybeg Lake, in the townland of Barntick, lies Cragmore Cave.

Bone Objects.—Just outside the mouth of the cave, among fallen blocks and the fragments of a human skull, lay an interesting specimen—a long cube-like object of horn (1), ornamented with the dots and concentric circles not uncommon in crannog finds. It was much worn at the edges, having evidently been long in use, perhaps for some game of chance or otherwise. On the end was a dot with two concentric circles: the upper surface had four dots, with single ring, arranged like a T, two across and two down the length of the block. A semicircle and an encircled dot were on the left, and a circled dot and the trace of a second on the end of the right side. Two circled dots were on the upper end, and one on the lower. It measured 1⅛ inch long, and ¼ inch wide (C. B. 1).

Other Objects.—A small iron stiletto, with traces of the wooden handle adhering, was found at the bottom of the upper stratum of earth. Peat was found in the inner boat-like chamber of this cave.

9. SUMMARY OF RESULTS.

By R. F. Scharff, Ph.D. B.Sc.

The caves which form the subject of these investigations are situated among beautiful surroundings in the County Clare, about thirty miles from the sea-coast. Like most of the Irish natural caves, they have originated by the solvent action of water on the limestone in which they occur. When the waters forsook the caves, probably finding some other more suitable channel, they soon became fit as habitations or shelters for Bears,

Wolves, Foxes, and Wild Cats, which may have dragged portions of their booty into the subterranean chambers to devour them at leisure.

We may assume that many of the bones of the Irish Elk, Reindeer, Wild Boar, Arctic Fox, and Arctic Lemming, as well as those of the Crane and other birds, found their way into the caves in that manner. At the same time, we have evidence that some of the bones are water-worn, and may have been introduced from above by running water. The occurrence in the caves of a shed antler of the Irish Elk and of long bones of this species, and of the Reindeer, some of which seem to show signs of having been artificially fractured, indicate the possible contemporaneousness of Man with these Deer. The evidence, however, is not conclusive. The Bear was clearly co-existent with Man. It probably lingered on in Ireland long after the Irish Elk and Reindeer had become extinct. Red Deer, Horse, Ox, Pig, Goat, and Sheep remains were brought into the caves as food by Man in more recent times. Some of the peculiar bone tools and the scrapers, which are of good form, may have been manufactured at a much earlier time; but the gold bracelet, bronze pin, and buckle belong to early Christian art, or what we may call the Danish Period.

There was no clear evidence as to the relation of the caves to the Glacial phenomena. It is possible that the caves existed already in pre-Glacial times.

The only important fact which the study of the human remains elicited is that some of the bones show indications that the people to whom they belonged habitually assumed the squatting posture, such as all the lower races are in the habit of doing. The bones otherwise revealed nothing which might lead us to suppose that they belonged to a different race from that inhabiting Ireland at the present time.

It is of interest to note that the teeth of the Wild Cat found agreed, not with the Wild Cat of Europe, but with that commonly met with throughout the African Continent, and popularly known as the Caffer Cat.

DESCRIPTION OF PLATES IV. AND V.

[*All the figures are natural size, except fig. 11, which is ¼th natural size.*]

PLATE IV.

FIG.

1. Crane, *Grus communis*. Radius, distal portion, Catacomb Cave.
2. ,, ,, ,, ,, proximal portion, Catacomb Cave.
3. ,, ,, ,, Seventh cervical vertebra, Catacomb Cave.
4. ,, ,, ,, Femur, proximal portion, Newhall Caves.
5. ,, ,, ,, Right coracoid, anterior and posterior views, Catacomb Cave.
6. Hawfinch ?, *Coccothraustes sp.* Three views of the anterior half of the mandible, Newhall Caves.
7. Arctic Fox, *Vulpes lagopus*. Left ramus of lower jaw, lateral view, and view from above, Newhall Caves.
8. Domestic Cat (small form), *Felis domestica*. Right ramus of lower jaw, Newhall Caves.
9. Irish Wild Cat, *Felis ocreata*. Right ramus of lower jaw, Newhall Caves.

PLATE V.

1–3. Bone pins, Newhall (N. H. 1 and 8) and Edenvale (E. A. 52).
4. Bone flake, Newhall (N. H. 129).
5. Bone implement, Newhall (N. H. 64).
6. Implement made from Boar's tusk, Edenvale (E. C. 65).
7–8. Teeth shaped for ornament, Newhall (N. H. 1).
9. Whorl made from femur of Ox, Newhall (N. H. 78).
10. Bear's tooth, cut, Newhall (N. H. 98).
11. Stone lamp (bottom and top), Newhall (N. H. 126).
12. Horn object, with dot-and-circle marks, Barntick (C. B. 1).
13. Clasp and loop of bronze (see buckle, p. 71, *supra*), Edenvale (E. C. 116).
14. Bronze wire bracelet, with details of loops (side and full views), Edenvale (E. A. 177).
15. "Thistle-headed" bronze pin, Newhall (N. H. 1).
16. Gold bracelet (side and full views), Edenvale.

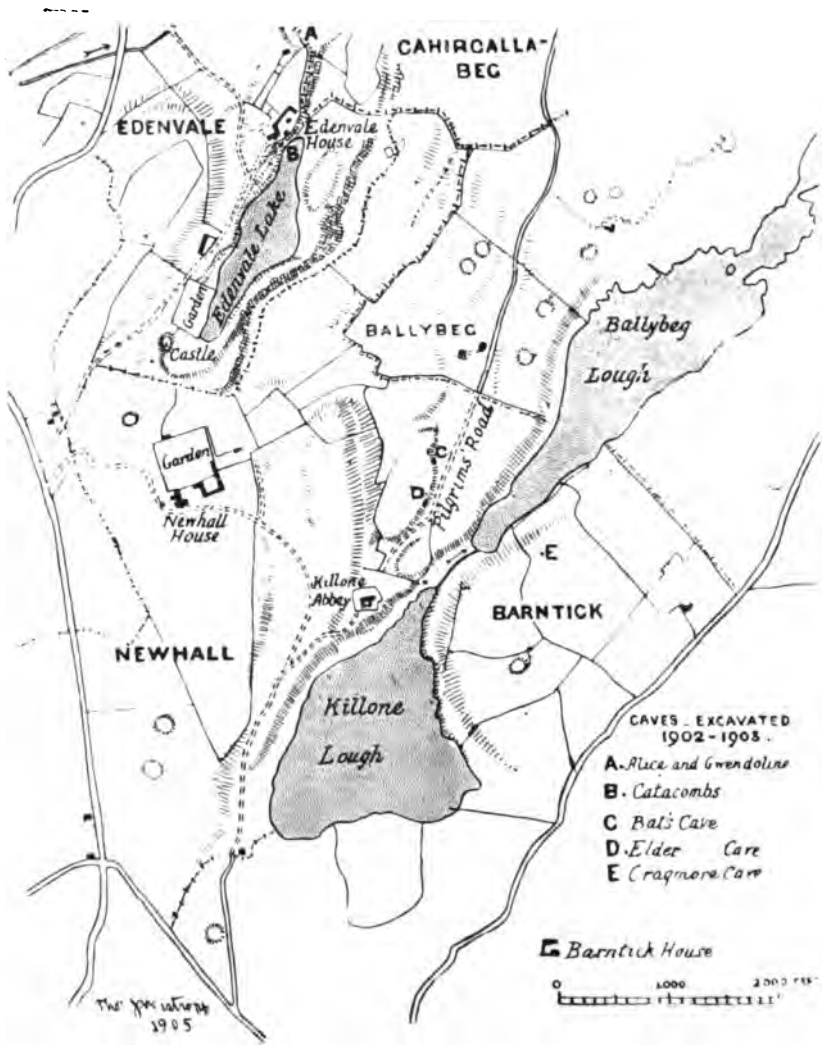


FIG. 1.—Map of district around Edenvale, Co. Clare, showing position of Caves.

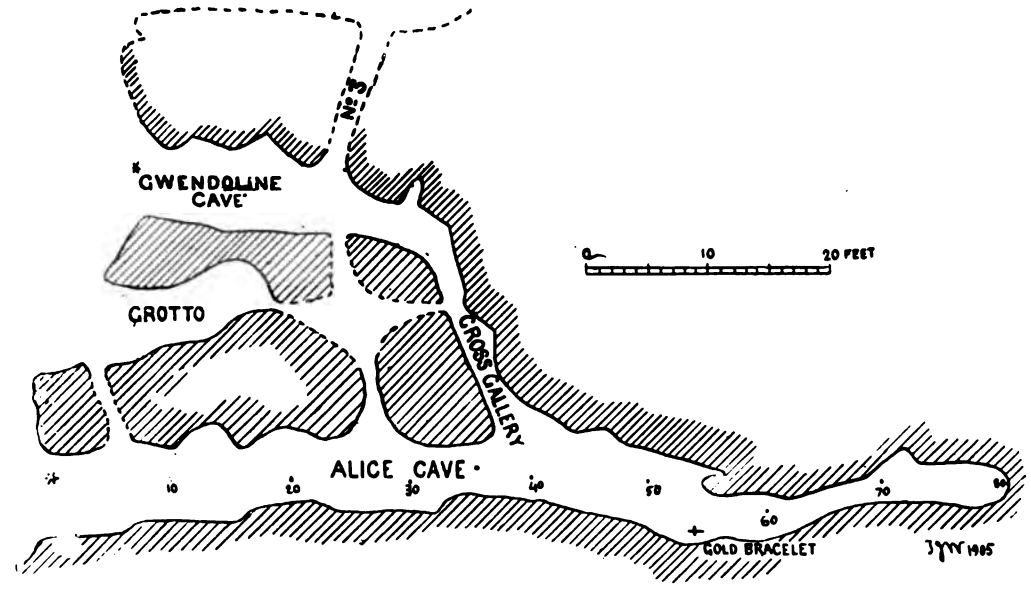


FIG. 2.—Plan of Alice and Gwendoline Caves, Edenvale.

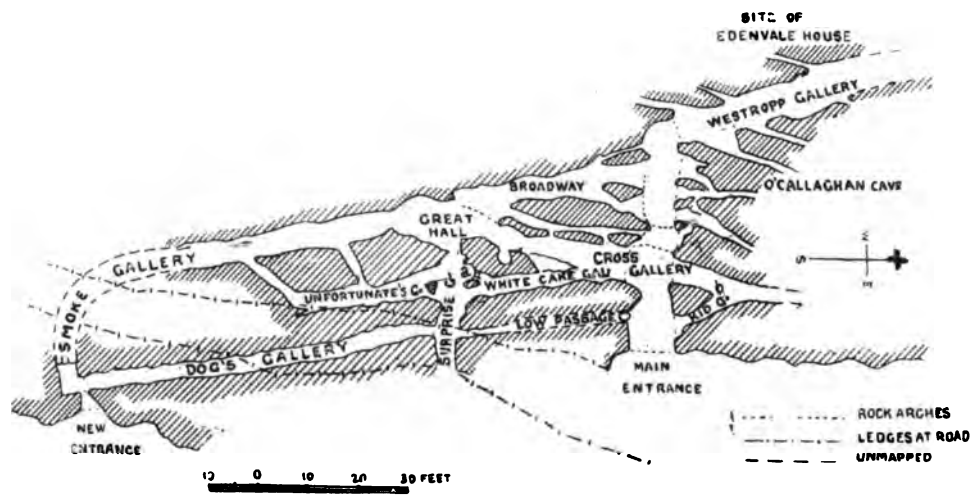


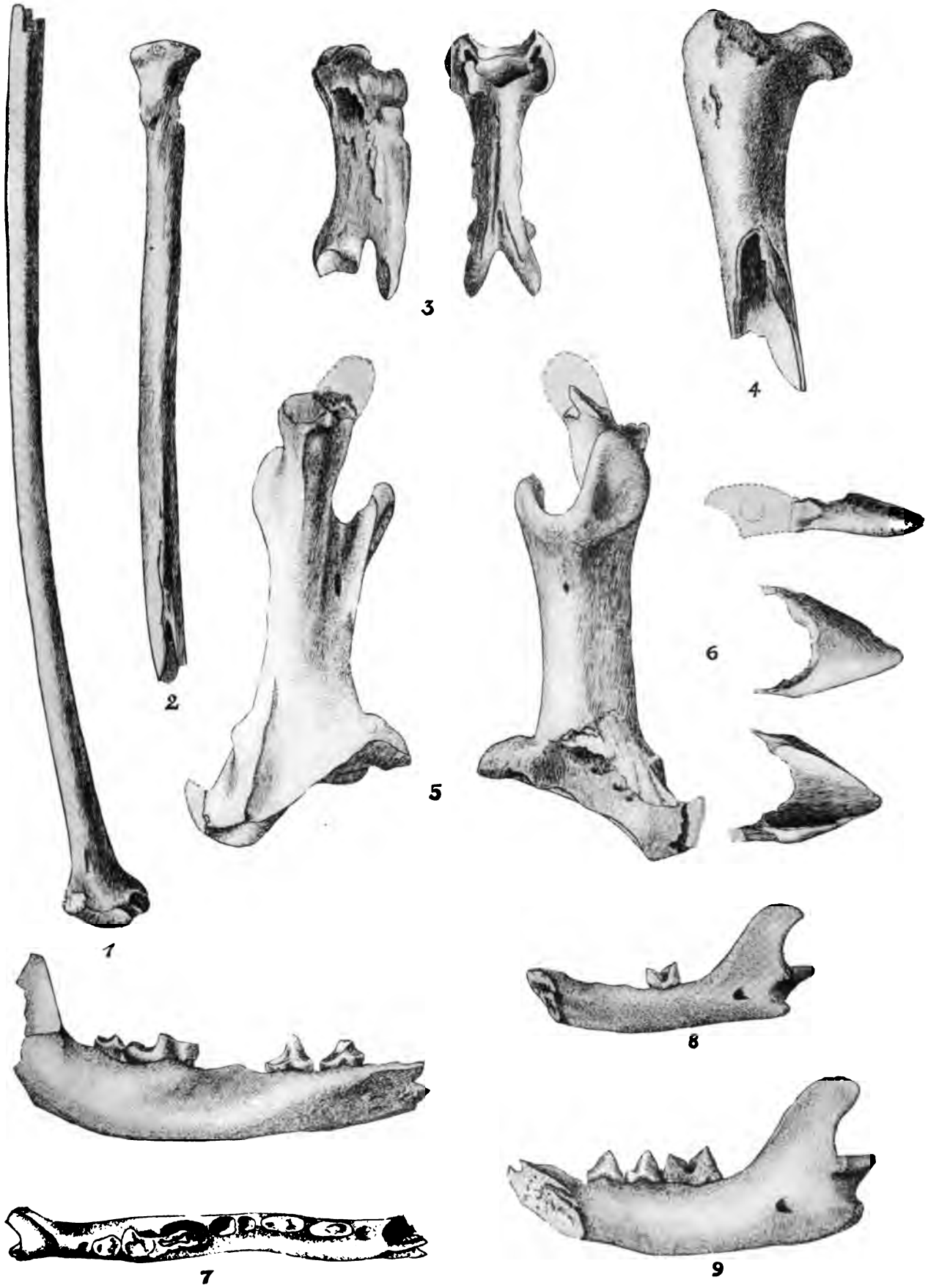
FIG. 3 --Plan of The Catacombs, Edenvale.

FIG. 1.—View showing entrances of Bats' Cave (A), and Elder-Bush Cave (B), Newhall. [*R. Welch, Photo.*

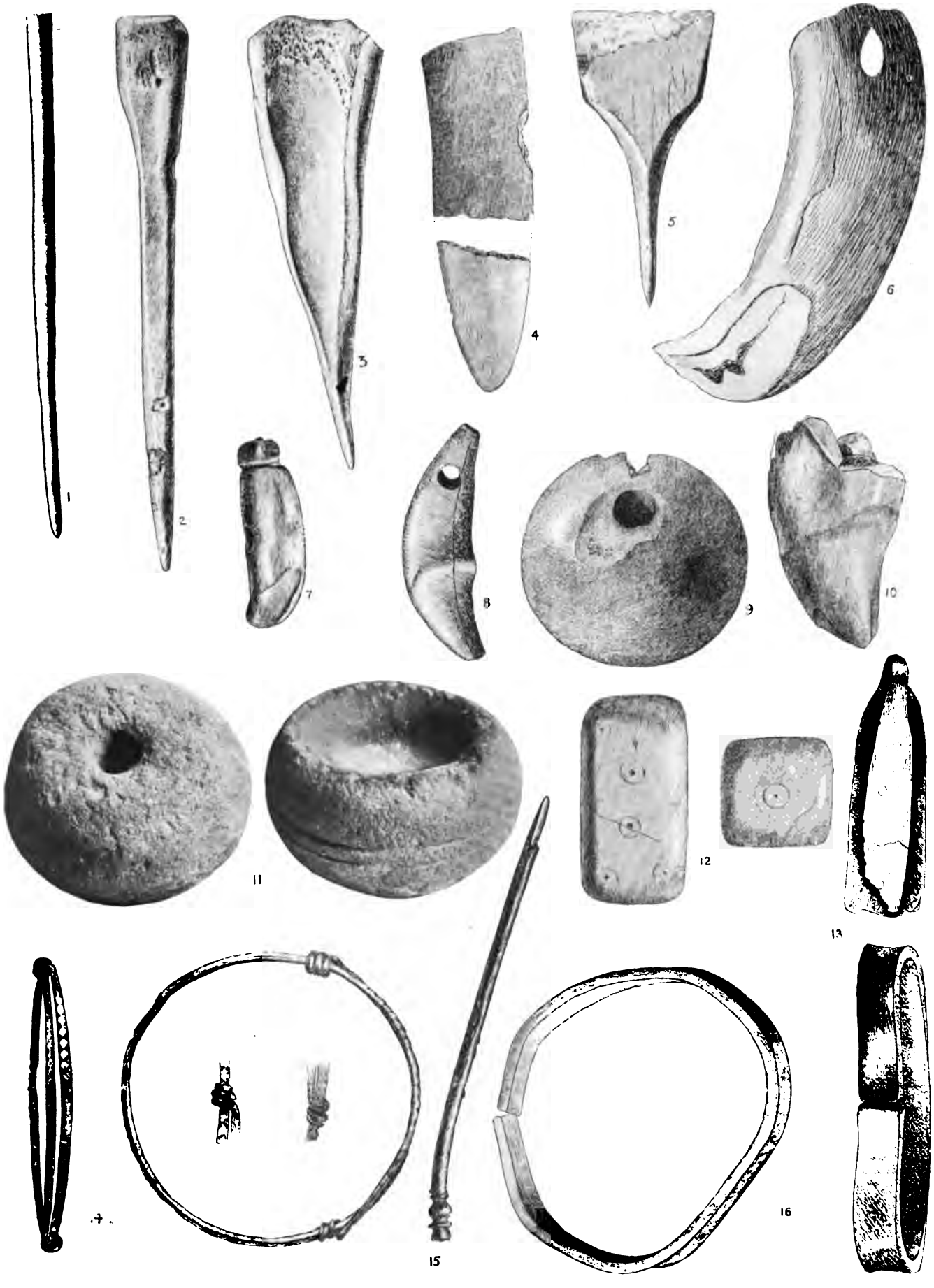
FIG. 2.—Entrance of The Catacombs, Edenvale. [*R. Welch, Photo.*

FIG. 1.—Entrance of Elder-Bush Cave, Newhall, Co. Clare, showing galleries at right angles and strong horizontal jointing. [*R. Welch, Photo.*

FIG. 2.—The Catacombs, Edenvale, looking in from a point 8 feet inside the mouth, showing cross-chambers and division walls. [*R. Welch, Photo.*



Animal Remains from Caves in Co. Clare.



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W. WEST AND G. S. WEST

A COMPARATIVE STUDY OF THE PLANKTON OF SOME IRISH LAKES

(PLATES VI.–XI.)

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II.

A COMPARATIVE STUDY OF THE PLANKTON OF SOME IRISH LAKES.

By W. WEST, F.L.S., and PROF. G. S. WEST, M.A., F.L.S.

(PLATES VI.–XI.)

(A Report from the Fauna and Flora Committee.)

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CONTENTS.

I. Introduction.

In 1902 we contributed to these Transactions a Paper on the Freshwater Algæ of the North of Ireland, which included an account of the phytoplankton of Lough Neagh and Lough Beg.* Since that date, by means of a grant from the Fauna and Flora Committee of the Royal Irish Academy, we have been able to further investigate the Alga-flora of Ireland.

The present Paper deals only with the plankton of some of the most important lakes in the west and south-west of the country, and we have contrasted the phytoplankton with that known from Lough Neagh and Lough Beg, and also with the Scottish phytoplankton. A large number of collections were made in Mayo, Galway, and Kerry,† and although Algæ were obtained from all available situations, the collection of plankton was made a special feature of the investigation. Some of the material was

* W. West and G. S. West: "A Contribution to the Freshwater Algæ of the North of Ireland." Trans. Roy. Irish. Acad., vol. xxxii., sect. B, part i., 1902, pp. 1–100, pl. 1–3.

† From the latter in May, 1904, and from the two former counties in August and September, 1904.

rich in variety of species, and we have thought it advisable to publish the results of the plankton investigations separately. Many of the pelagic organisms were of great interest, and some of them have never before been observed in the British Islands. Several we have had to regard as entirely new species.

With the exception of Lough Acorrymore in Achill Island, Mayo, almost all the lakes examined were very little above the sea-level.

We have to thank Mr. E. Lemmermann, of Bremen, for his kindness and courtesy in examining some of the Peridinieæ, Rotifers, and Entomostraca, and also for giving us his valuable opinion on a few of the Algæ.

We hope, in a future contribution, to give an account of the remainder of the collections of Algæ, exclusive of the plankton.

II. Detailed Account of the Plankton of the Loughs investigated.

Plankton has been collected and examined from sixteen of the Irish loughs, the following brief notes giving the principal features of each lough, with mention of any peculiarities exhibited by the plankton, and the dominant forms contained therein. The dates indicate the days on which the material was collected.

1. *Lough Conn, Mayo*, Aug. 31st, 1904.—This lough is about 8 miles in length and averages about $2\frac{1}{2}$ miles in width. The shores are mostly rocky, and the plankton was obtained in a high wind with large waves on the lough. The collections contained numerous Entomostraca, and the Rotifers *Notholca longispina* Kellicot, and *Anuræa cochlearis* Gosse were very common. Of the phytoplankton, *Asterionella formosa* Hass. and *Melosira varians* Ag. were present in large quantity. *Ceratium hirundinella* O. F. M. was also abundant. Fragmentary colonies of *Glæocapsa magna* (Bréb.) Kütz. occurred in the material, but these had most probably been torn from the rocks at the shores by the violence of the waves.

2. *Lough Cullin, Mayo*, Aug. 31st, 1904.—This lough lies to the south of Lough Conn, but is connected with that lake by a wide channel across which is a pontoon bridge. It is about 3 miles in length and $2\frac{1}{2}$ miles in

width, and, like the adjacent lough, its shores are very rocky. The plankton had a very different appearance from that collected in Lough Conn on the same day. The material was of a dark-green colour, due to a large quantity of floating masses of the spores of *Anabæna Lemmermanni* Richter. Another feature of this plankton was the presence of large contorted filaments of *Anabæna circinalis* (Kütz.) Rabenh., and there was also a great profusion of *Asterionella formosa* Hass. The Entomostraca consisted mostly of a small species of *Bosmina*. The Rotifers *Notholca longispina* Kellicot, *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb. were general, and *Ceratium hirundinella* O. F. M. and *Mallomonas acaroides* Perty were abundant.

3. *Lough Keel, Achill Island, Mayo*, Aug. 28th, 1904.—This is an uninteresting lough about a mile in length and half a mile wide at its broadest part. It is only separated from the sea by a flat belt of land about half a mile in width, and the water is very shallow. The plankton, which was collected close to the eastern shore, contained large numbers of *Cyclops*, all of which were thickly coated with *Characium Debaryanum* (Reinsch) De Toni. The Rotifers *Notholca longispina* Kellicot and *Anuræa cochlearis* Gosse occurred in small quantity, and a few specimens of *Ceratium hirundinella* O. F. M. were observed. The principal constituents of the phytoplankton were *Pediastrum Boryanum* (Turp.) Menegh., *Eunotia pectinalis* (Kütz.) Rabenh. in long ribbons, *Chroococcus limneticus* Lemm., and a small form of *Staurastrum gracile* Ralfs.

4. *Lough Acorrymore, Achill Island, Mayo*, Aug. 28th, 1904.—This is a small lough, not more than half a mile in length, and situated about 700 ft. above sea-level in a deep hollow of Croaghaun. Its margins are rocky, and the plankton was obtained from near its outlet. The only Entomostracan observed was *Bosmina longirostris* O. F. M., and the three Rotifers *Notholca longispina* Kellicot, *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb. occurred plentifully. *Ceratium hirundinella* O. F. M was also frequent. Long filaments of *Sphærozosma Aubertianum* West were abundant, and likewise matted filaments of *Microspora amæna* (Kütz.) Rabenh. var. *irregularis* nob. and *Eunotia pectinalis* (Kütz.) Rabenh.

5, 6, and 7. *Small lakes between Clifden and Roundstone, Galway*, Sept. 5th,

1904.—There is an area between Clifden and Roundstone, occupying about 30 square miles, and across the northern part of which a road has been constructed, which presents one of those rocky bog-lands which are a feature of western Sutherland and the Outer Hebrides. The bogs are practically impassable, and the entire area is studded with small lakes. Many of these lakes possess rocky shores, and the bogs themselves are rocky. It is possible to step from a solid mass of granitic rocks into knee-deep bog, and it is quite impossible to reach the margins of some of the lakes. The bogs and lakes contain quantities of *Eriocaulon septangulare* With. and *Utricularia minor* L., and the district is one of the richest in Ireland for freshwater Algæ. We obtained plankton from three of these lakes, one of which was certainly more than a mile in length. The material contained numerous Entomostraca and Nauplii, and a great abundance of *Ceratium hirundinella* O. F. M., many of the latter being of a rather remarkable shape. The Rotifers *Notholca longispina* Kellicot, *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb., were scarce. The plankton of these lakes more nearly resembled that of the small lakes in the west and north-west of Scotland (especially the Outer Hebrides) than any other we have collected in Ireland. The Desmids in particular were very similar, and with few exceptions most of the characteristic species of the Scottish plankton were present. One of the lakes contained a large quantity of floating *Stigonema minutum* Hass., a species which occurred in similar abundance in the lakes of north-west Scotland. The occurrence of *Peridinium limbatum* (Stokes) Lemm. is of great interest.

8. *Lough Mawmeen, west of Roundstone, Galway*, Sept. 5th, 1904.—This lake is about $4\frac{1}{2}$ miles due west of Roundstone, and is one of the largest and most southerly of the lakes of the area between Clifden and Roundstone described above. Numerous Entomostraca occurred, of which the most abundant was *Sida crystallina* O. F. M. The plankton was remarkable for the great abundance of *Eudorina elegans* Ehrenb., *Ceratium hirundinella* O. F. M., *Cœlosphærium Kützingianum* Näg., and *Anabæna circinalis* (Kütz.) Rab. var. *tenuis*. Long filaments of *Gonatozygon Kinahani* (Arch.) Rabenh. were by no means uncommon. The three Rotifers *Notholca longispina* Kellicot, *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb. were very scarce.

9. *Lough Corrib, Galway*, Sept. 7th, 1904.—This is one of the largest lakes in the British Islands, and much the largest in the west of Ireland. It is about 20 miles in length, and varies in breadth from half a mile to 7 miles. The southern end of the lake, which is about 4 miles across, is very shallow; but the northern and larger part of the lake is much deeper. The plankton was obtained from among the islands which stud the lake to the north-east of Oughterard, and the material was collected in a strong wind. The dominant feature of the plankton was the abundance of *Gomphosphæria lacustris* Chodat, *Asterionella formosa* Hass., *Synedra Lemmermanni* sp. n., and certain Desmids. *Cyclotella Schroeteri* Lemm. was also abundant, forming chains, the individuals being remote from each other and held in position by a thick cylinder of mucus. The Rotifers *Notholca longispina* Kell., *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb. were fairly numerous, and also two forms of *Ceratium hirundinella* O. F. M. *Mallomonas acaroides* Perty was not uncommon.

10. *Lough Caragh, Kerry*, May 24th, 1904.—This lough is about 4 miles in length, and varies in width from one-quarter to three-quarters of a mile. It is about 4 miles south-west of Killorglin, and is situated close to the sea. Entomostraca were very numerous, large specimens of *Bosmina cornuta* Jur., *Holopedium gibberum* Zaddach, *Polyphemus pediculus* de Geer, and numerous Nauplii being the most conspicuous. *Mallomonas caudata* Iwanoff, and a form of *Ceratium hirundinella* O. F. M. were not uncommon. *Notholca longispina* Kell. and *Anuræa cochlearis* Gosse were fairly numerous. *Sphærocystis Schroeteri* Chodat was in great abundance, and also many Desmids, but of the latter no single species was conspicuously in excess.

11. *Lough Currane, Kerry*, May 25th, 1904.—This lough is quite close to the sea in Ballinskelligs Bay, the town of Waterville being situated at its outlet. It is about $2\frac{1}{2}$ miles long by $2\frac{1}{4}$ miles wide. The plankton contained numerous *Bosmina longirostris* O. F. M. and Nauplii. *Notholca longispina* Kell. and *Anuræa cochlearis* Gosse occurred in quantity, but *Polyarthra platyptera* Ehrenb. was very scarce. *Mallomonas acaroides* Perty was abundant, and a form of *Ceratium hirundinella* O. F. M. was not uncommon. Apart from the Entomostraca and Rotifers, the most conspicuous features of the plankton were the profusion of *Tabellaria*

fenestrata (Lyngb.) Kütz., in long zigzag chains, the abundance of *Sphærocystis Schroeteri* Chodat, and the presence of numerous Desmids.

12. *Lough Derriana, Kerry*, May 26th, 1904.—This lough is about 7 miles north-east of Waterville on the right of the road to Killorglin. It is about 2 miles in length and three-quarters of a mile in width. The dominant features of the plankton were quantities of zigzag chains of *Tabellaria fenestrata* (Lyngb.) Kütz., and large numbers of *Staurastrum jaculiferum* West, *St. cuspidatum* Bréb. var. *maximum* West, and *St. paradoxum* Meyen. *Anuræa cochlearis* Gosse occurred only in small quantity, and *Ceratium hirundinella* O. F. M. was very scarce.

13. *Lough Guitane, Kerry*, May 23rd, 1904.—This is one of the lakes in the Killarney district, and is situated east-south-east of Lough Leane. It is about 1½ miles in length and 1 mile in width. The principal features of the plankton were large numbers of Nauplii, quantities of *Anabæna circinalis* (Kütz.) Rabenh., and a great abundance of *Staurastrum jaculiferum* West and *St. curvatum* West. *Notholca longispina* Kell., *Anuræa cochlearis* Gosse, and *Polyarthra platyptera* Ehrenb. were common, but *Ceratium hirundinella* O. F. M. was scarce.

14. *Lough Leane (or the Lower Lake of Killarney), Kerry*, May 22nd, 1904. —This lake is about 5 miles in length and about 2½ miles broad at its widest part. The dominant features of the plankton were long ribbons of *Fragilaria capucina* Desmaz. and a great abundance of *Tabellaria fenestrata* (Lyngb.) Kütz. var. *asterionelloides* Grun. *Bosmina longirostris* O. F. M., *B. cornuta* Jur., *Polyphemus pediculus* de Geer, and numerous Nauplii were present. The Rotifers *Notholca longispina* Kell., *Anuræa cochlearis* Gosse, and *Triarthra longiseta* Ehrenb. were fairly abundant, as were also *Ceratium hirundinella* O. F. M. and *Mallomonas acaroides* Perty. *Closteriopsis longissima* Lemm. was not uncommon, and the presence of the Protozoan *Tintinnidium fluviatile* Stein was very interesting.

15. *Lough Neagh.*—The plankton-collections were made during May, 1900, and July, 1901, and have been partially reported upon in the Trans. Roy. Irish Acad., vol. xxxii., part i., 1902, pp. 5–10. Since this account was published much time has been spent at further work on the material, and many additions have been noted. The original list (including the

plankton of the Lower River Bann at the outlet of Lough Neagh), with the additions, is inserted in the general table of phytoplankton for comparison with the lakes of the west and south-west. Lough Neagh is the largest lake in the British Islands, being from 14 to 18 miles in length and averaging about 10 miles in width. It is a shallow lake, the average depth being about 45 feet, the deepest sounding in the north-west corner being only 96 feet. The plankton was chiefly remarkable for the great abundance of *Tabellaria fenestrata* (Lyngb.) Kütz. var. *asterionelloides* Grun. and *Staurastrum paradoxum* Meyen var. *longipes* Nordst., both of which occurred in prodigious quantities. *Pediastrum duplex* Meyen and *Gomphosphæria lacustris* Chodat were also present in abundance. The three Rotifers *Anuræa cochlearis* Gosse, *A. aculeata* Ehrenb., and *Notholca longispina* Kell. were general. *Bosmina longirostris* O. F. M. and *Cyclops* sp. occurred sparingly. *Ceratium hirundinella* O. F. M., *Peridinium cinctum* Ehrenb., and *P. tabulatum* (Ehrenb.) Clap. et Lach. were abundant.

16. *Lough Beg, Londonderry*, July, 1901.—After leaving Lough Neagh, the Lower River Bann expands into Lough Beg, a very shallow lake, averaging only about 5 feet in depth. It is about $3\frac{1}{2}$ miles in length by about a mile in average breadth, and the plankton presents a great similarity to that of Lough Neagh. The collections were partially reported upon in 1902, along with the report upon the plankton of Lough Neagh. Since then many additions have been found, and the entire list is tabulated along with the other lists of phytoplankton. *Anuræa cochlearis* Gosse and *A. aculeata* Ehrenb. were not uncommon, and *Ceratium hirundinella* O. F. M., *Peridinium cinctum* Ehrenb., and *P. tabulatum* (Ehrenb.) Clap. et Lach. were fairly common. Again, the leading feature was the enormous abundance of *Tabellaria fenestrata* (Lyngb.) Kütz. var. *asterionelloides* Grun.

17. The column numbered 17 in the table of phytoplankton is inserted so that a direct comparison can be made between the species occurring in the plankton of the west of Scotland, and those occurring in the plankton of the western and south-western lakes of Ireland. It does not include all the forms observed in the Scottish freshwater plankton, but only those known from the Irish plankton which likewise occur in Scotland.

TABLE OF PHYTOPLANKTON.

The Algæ noted as occurring in the various collections have been tabulated to facilitate comparison. The relative frequency of a species is indicated by the letters "ccc" = very abundant, "cc" = common, "c" = fairly common, "r" = infrequent, "rr" = rare, and "rrr" = very rare. The × in column No. 17 indicates that the particular form in question is known to occur in the freshwater plankton of the west of Scotland.

Species.	Mayo.				Galway.					Kerry.							
	Lough Conn.	Lough Cullin.	Lough Keel, Achill Island.	Lough Acorrymore, Achill Island.	Small lakes between Clifden and Roundstone. I.	II.	III.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.	Lough Beg, Londonderry.	West of Scotland.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Phæophyceæ.																	
Phæococcus planctonicus, W. & G. S. West,	..	..	..	..	..	..	..	..	..	r	rr	..	..	..	..	..	×
Dinobryon cylindricum, Imhof,	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..
,, ,, var. divergens (Imhof), Lemm.,	r	c	..	..	c	cc	..	c	..	c	ccc	rr	..	r	c	r	×
,, ,, var. palustre, Lemm.,	..	..	..	..	r	..	..	r	..	..	..	..	..	..	..	..	×
,, ,, var. Schauinslandii, Lemm.,	..	..	..	..	..	..	..	..	..	..	r	..	..	..	..	..	×
,, sociale, Ehrenb.,	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..
,, Sertularia, Ehrenb., var. thrysoideum (Chod.) Lemm.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..
,, protuberans, Lemm.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	×
,, elongatum, Imhof,	..	..	..	..	r	rr	..	..	rr	rr	..	..	..	..	..	..	×
,, ,, var. undulatum, Lemm.,	..	..	..	..	..	..	..	..	r	..	rr	..	..	..	..	..	×
,, bavaricum, Imhof,	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..
Chlorophyceæ.																	
Œdogonium, spp. (sterile),	..	..	..	..	cc	cc	r	cc	c	..	..	rr	rrr	..	rr	r	×
Ulothrix subtilis, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
,, ,, var. variabilis (Kütz.), Kirchn.,	..	..	..	c	..	..	..	..	..	..	..	..	..	..	..	..	×
Geminella interrupta, Turp.,	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	×
Myxonema subsecundum (Kütz.), Hazen,	..	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..	..
,, tenue (Ag.), Rabenh.,	..	..	..	..	..	..	..	..	..	r	..	..	..	..	r	..	..
Microspora amœna (Kütz.), Rabenh.,	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, ,, var. irregularis, var. n.,	..	..	rr	c	..	..	..	..	..	..	..	..	..	..	..	..	×
Mougeotia, spp. (sterile),	cc	r	r	c	cc	cc	ccc	cc	cc	rr	rr	r	rr	r	r	r	×
Zygnema, spp. (sterile),	..	..	..	..	..	..	..	rr	rr	..	..	rr	..	..	..	..	×
Spirogyra, spp. (sterile),	rrr	..	..	..	r	c	..	r	rrr	rrr	rr	..	rrr	c	..	..	×
Gonatozygon monotænium, De Bary,	r	..	..	..	r	c	c	rr	..	r	rr	..	..	..	..	..	×
,, ,, var. pilosellum, Nordst.,	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	×
,, Kinahani (Arch.), Rabenh.,	..	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..	×
,, aculeatum, Hastings,	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	×
Mesotœnium macrococcum (Kütz.), Roy & Biss.,	..	..	..	..	rrr	r	..	..	..	..	..	..	..	..	..	..	×
Netrium Digitus (Ehrenb.), Itzigsh. & Rothe,	r	..	..	..	rr	..	..	..	..	..	..	..	rrr	..	..	..	×
Penium Libellula (Focke), Nordst.,	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	×

,, minutum (Ralfs), Cleve,	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..	..	×
Closterium Pseudodianæ, Roy,	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, parvulum, Näg.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, Leibleinii, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	×
,, acerosum, (Schr.), Ehrenb. var. minus Hantzsch,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	×
,, decorum, Bréb.,	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, acutum, Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..	×
,, Ceratium, Perty,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	×
,, pronum, Bréb.,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
,, aciculare, T. West var. subpronum W. & G. S. West,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	r	..	..	..	×
,, Kützingii, Bréb.,	..	..	..	..	..	..	..	..	..	r	rr	rr	r	r	..	..	..	..	×
,, ,, var. onychosporum W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	..	rr	r	..	..	..	..	..	×
Pleurotænium Ehrenbergii (Ralfs), De Bary,	..	..	..	..	rr	..	..	rr	..	..	..	..	..	..	..	..	..	..	×
Tetmemorus granulatus (Bréb.), Ralfs,	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Euastrum ansatum Ralfs,	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, elegans (Bréb.), Kütz.,	rr	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	×
,, bidentatum Näg.,	..	..	..	..	r	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
,, denticulatum (Kirchn.), Gay,	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	×
,, verrucosum Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, ,, var. reductum Nordst.,	..	..	rr	..	..	..	..	..	..	rr	rr	..	..	..	..	..	..	..	×
Micrasterias truncata (Corda), Bréb.,	..	..	..	..	rrr	..	rr	..	..	..	..	..	..	..	..	..	..	..	×
,, papillifera Bréb.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, Sol (Ehrenb.) Kütz.,	..	..	..	..	rr	rr	r	..	..	..	rr	..	..	..	..	..	..	..	×
,, ,, var. ornata Nordst.,	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..	..	×
,, denticulata Bréb.,	..	..	..	..	r	r	..	..	..	..	..	..	..	..	..	..	..	..	×
,, radiata Hass.,	..	..	..	..	..	rr	rrr	..	..	..	..	..	..	..	..	..	..	..	×
Cosmarium subtumidum Nordst. var. Klebsii (Gutw.) W. & G. S. West,	rr	rr	..	..	..	..	..	..	c	..	..	..	..	..	rr	rr	..	..	×
,, depressum (Näg.), Lund.,	..	..	..	..	c	r	r	rr	cc	..	rr	..	..	..	r	..	..	..	×
,, bioculatum Bréb.,	..	..	..	..	..	..	..	..	..	c	..	r	rr	..	..	..	..	..	×
,, subarctoum (Lagerh.), Racib.,	..	..	..	..	..	..	..	..	..	c	cc	..	cc	..	..	..	..	..	×
,, Corribense sp. n.,	..	..	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..	..	×
,, contractum Kirchn.,	..	..	..	..	c	r	c	..	..	rr	rr	..	r	..	..	..	..	..	×
,, ,, var. ellipsoideum (Elfv.), W. & G. S. West,	..	..	..	..	..	cc	..	..	..	..	..	..	rr	..	..	..	..	..	×
,, granatum Bréb.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, ,, var. subgranatum Nordst.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	×
,, Meneghinii Bréb. forma octangularis Wille,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, difficile Lütkem. var. sublæve Lütkem.,	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	×
,, capitulum Roy & Biss. var. grœnlandicum Börges.,	..	..	..	..	..	..	rr	..	..	rr	..	..	..	..	..	..	..	..	×
,, abbreviatum Racib. var. planctonicum W. & G. S. West,	rr	..	..	..	..	..	..	..	r	c	c	rr	..	rr	rr	..	..	..	×
,, moniliforme (Turp.) Ralfs,	..	..	..	..	cc	c	cc	r	c	..	..	..	..	..	..	..	..	..	×
,, connatum Bréb.,	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	×
,, humile Gay,	..	..	rr	..	rr	..	..	..	..	..	..	..	..	..	rr	..	..	..	×
,, punctulatum Bréb.,	..	..	..	..	rr	..	rr	r	r	..	..	..	..	..	..	..	..	..	×
,, margaritiferum (Turp.), Menegh.,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
,, reniforme (Ralfs), Arch.,	..	..	..	..	..	..	..	..	rrr	..	..	..	rrr	..	..	..	..	..	×
,, Botrytis (Bory), Menegh.,	..	r	..	..	..	..	..	..	rrr	..	..	..	..	r	r	..	..	..	×
,, ,, var. depressum W. & G. S. West,	..	..	..	..	..	..	..	..	rr	rrr	..	..	..	..	..	..	..	..	×
,, tetraophthalmum Bréb.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, Brébissonii, Menegh.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	×
,, ovale, Ralfs,	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	×
,, Turpinii, Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	r	rr	..	..	×
,, ornatum, Ralfs,	..	..	..	..	rr	..	..	..	..	..	rrr	..	..	..	..	..	..	..	×
Cosmocladium Saxonicum, De Bary,	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Xanthidium antilopæum (Bréb.), Kütz.,	..	..	..	..	r	c	c	r	rr	r	..	..	..	..	rr	..	..	..	×
,, ,, var. depauperatum, W. & G. S. West,	..	..	..	..	..	..	..	..	r	rr	..	..	..	rr	..	..	..	..	×
,, ,, var. Hebridarum, W. & G. S. West,	..	..	..	..	c	cc	r	..	..	..	..	..	..	..	..	..	..	..	×
,, subhastiferum, West,	..	..	..	..	r	..	..	..	..	c	cc	rr	c	r	..	..	..	..	×
,, cristatum, Bréb.,	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, armatum (Bréb.), Rabenh.,	..	..	..	..	rrr	rrr	..	..	rrr	..	..	..	..	..	..	..	..	..	×
Arthrodesmus Incus (Bréb.), Hass.,	..	..	..	..	r	r	c	..	rrr	r	r	..	..	..	..	..	..	..	×
,, triangularis, Lagerh.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, ,, var. subtriangularis (Borge), W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
Arthrodesmus crassus, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	×

TABLE OF PHYTOPLANKTON—*continued.*

Species.	Mayo.				Galway.					Kerry.							
	Lough Conn.	Lough Cullin.	Lough Keel, Achill Island.	Lough Acorrymore, Achill Island.	Small lakes between Clifden and Roundstone. I.	Small lakes between Clifden and Roundstone. II.	Small lakes between Clifden and Roundstone. III.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.	Lough Beg, Londonderry.	West of Scotland.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chlorophyceæ—*continued.*																	
Staurastrum apiculatum, Bréb.,	..	..	..	..	..	..	..	..	rrr	..	rr	..	..	..	rr	..	..
,, dejectum, Bréb.,	..	..	rr	..	..	..	r	rr	..	..	r	..	..	..	r	r	×
,, var. inflatum, West,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	r	rr	×
,, Dickiei, Ralfs,	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	×
,, curvatum, West,	r	rr	..	..	..	rr	c	r	rr	c	c	..	cc	rr	..	..	×
,, jaculiferum, West,	..	..	rrr	..	..	..	..	..	..	r	cc	cc	ccc	r	..	..	×
,, ,, var. excavatum, W. & G. S. West.	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	×
,, megacanthum, Lund.,	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	×
,, cuspidatum Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	×
,, ,, var. maximum, West,	..	..	r	..	..	..	..	..	..	r	cc	c	r	..	r	..	×
,, longispinum (Bail.), Arch.,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	×
,, Brasiliense Nordst. var. Lundellii, W. & G. S. West,	..	..	..	..	r	r	..	..	..	..	rr	..	..	..	..	..	×
,, grande, Buln.,	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	×
,, muticum, Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	×
,, subpygmæum, West,	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	×
,, brevispinum, Bréb.,	rr	..	..	..	..	..	rr	rr	c	..	r	..	..	c	c	c	×
,, ,, var. altum, W. & G. S. West,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
,, aversum, Lund.,	..	..	..	..	r	rr	..	..	rrr	..	..	..	..	..	..	..	×
,, lunatum, Ralfs, var. planctonicum, W. & G. S. West,	..	..	..	..	..	rrr	..	..	c	rr	cc	r	cc	c	..	..	×
,, Avicula, Bréb., var. subarcuatum (Wolle), West,	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	×
,, denticulatum (Näg.), Arch.,	r	..	..	..	..	..	..	..	..	c	..	c	..	..	..	..	×
,, granulosum (Ehrenb.), Ralfs,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	rr	×
,, Bieneanum, Rabenh.,	..	..	..	..	..	..	..	..	..	rr	rr	..	..	..	..	..	×
,, brachiatum, Ralfs,	..	..	..	..	c	..	..	..	..	rrr	r	..	..	..	..	..	×
,, dilatatum, Ehrenb., var. obtusilobum, De Not.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	×
,, Maamense, Arch.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	×
,, hexacerum (Ehrenb.), Wittr.,	..	..	..	..	..	..	..	..	..	..	..	rrr	..	rrr	..	..	×
,, pelagicum, W. & G. S. West,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	c	r	×
,, pseudopelagicum, W. & G. S. West,	..	..	..	..	..	..	..	..	..	c	rr	rr	..	..	..	..	×
,, paradoxum, Meyen,	..	rr	rr	c	..	..	..	..	r	cc	..	cc	..	cc	..	r	×
,, ,, var. longipes, Nordst.,	c	r	..	..	r	c	c	..	c	rr	r	r	c	rr	cc	c	×
,, ,, var. cingulum, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	×
,, gracile, Ralfs,	..	..	c	c	r	c	..	rr	..	r	r	c	rr	r	r	rr	×
,, ,, var. cyathiforme, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	×
,, dorsidentiferum, sp. n.,	c	c	..	..	..	..	..	..	r	..	..	..	..	..	..	..	×
,, anatinum, Cook & Wills,	..	..	..	..	c	cc	c	..	rr	r	c	r	rr	r	r	rr	×
,, ,, var. truncatum, West,	..	..	..	..	..	..	..	..	..	..	c	..	c	..	r	rr	×
,, ,, var. pelagicum, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	r	×
,, Sebaldi, Reinsch, var. productum, W. & G. S. West,	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	×
,, ,, var. ornatum, Nordst.,	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	rrr	..	×
.. Manfeldtii, Delp.,	..	..	..	r	..	..	..	..	..	..	..	..	..	..	..	..	×
.. Arachne, Ralfs,	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	×
.. Tohopekaligense, Wolle, var. triforcatum, W. & G. S. West,	..	..	..	..	rr	..	rrr	r	..	..	..	..	..	..	..	..	×

,, furcigerum, Bréb.,	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	rr	rr	×
,, ,, var. reductum, var. n.,	..	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	×
,, sexangulare (Bulnh.), Rabenh.,	..	..	..	..	..	r	r	..	..	..	..	rr	..	..	..	..	..	..	×
,, Arctiscon (Ehrenb.), Lund.,	..	..	..	..	r	..	..	..	..	..	..	rr	c	r	rr	..	..	..	×
Spondylosium pulchrum (Bail.), Arch., var. planum, Wolle,	rr	..	..	..	..	..	..	..	rr	cc	c	rr	cc	rr	..	..	..	..	×
Sphærozosma vertebratum, Ralfs,	rr	rr	..	..	c	..	..	..	rr	..	..	..	c	..	..	..	..	..	×
,, Aubertianum, West,	..	..	..	ccc	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, excavatum, Ralfs,	..	..	..	..	..	rr	..	..	c	..	..	..	..	..	..	..	..	..	..
Desmidium Pseudostreptonema, W. & G. S. West,	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..
Gymnozyga moniliformis, Ehrenb.,	..	..	..	..	..	c	..	..	..	..	..	..	rr	..	..	..	..	..	×
Hyalotheca dissiliens (Sm.), Bréb.,	..	..	..	..	..	r	r	..	..	rr	..	..	..	..	..	..	..	..	..
,, Indica, Turn.,	..	..	..	..	r	rr	..	..	..	..	..	..	..	..	..	..	..	..	×
,, mucosa, Ehrenb.,	rr	..	..	..	c	rr	r	r	..	..	..	..	r	..	..	..	..	..	×
,, neglecta, Racib.,	..	..	..	..	..	r	rr	..	..	..	..	..	..	..	..	..	..	..	×
,, undulata, Nordst.,	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	×
Volvox aureus, Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..
Eudorina elegans, Ehrenb.,	rrr	rr	..	..	r	c	..	ccc	c	..	..	..	..	..	..	r	r	×	..
Chlamydomonas pulvisculus, Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..
Characium Debaryanum (Reinsch), De Toni,	..	..	ccc	rr	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..
Pediastrum Boryanum (Turp.), Menegh.,	c	r	c	..	c	..	r	..	rrr	..	rrr	r	rr	c	c	cc	×	..	..
,, ,, var. granulatum, Ralfs,	r	..	..	..	..	..	..	..	..	..	..	..	..	..	r	c	c	..	..
,, ,, var. longicorne, Reinsch,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..
,, ,, var. brevicorne, A. Br.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..
,, constrictum, Hass.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
,, duplex, Meyen,	..	..	..	..	..	..	..	..	c	..	..	..	..	..	..	c	c	×	..
,, ,, var. asperum, A. Br.,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	rr	rr	..	..
,, ,, var. clathratum, A. Br.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c	c	..	..
,, Tetras (Ehrenb.), Ralfs,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	rrr	×	..
Cœlastrum cambricum, Arch.,	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	×	..
,, microporum, Näg.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..
,, sphæricum, Näg.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	×	..
,, reticulatum (Dang.), Senn,	..	r	..	..	..	..	..	..	..	..	..	..	..	..	rr	rrr	rr	..	..
Crucigenia quadrata, Morren,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..
,, rectangularis (Näg.), Gay,	r	c	..	..	..	..	rr	c	cc	..	..	..	..	..	..	..	..	×	..
,, Tetrapedia (Kirchn.), W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	rrr	..	..	..
Scenedesmus bijugatus (Turp.), Kütz.,	rrr	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	×	..
,, ,, forma arcuatus (Lemm.), nob.,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..
,, quadricauda (Turp.), Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	rr	..	..	×	..
,, ,, var. abundans, Kirchn.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..
,, ,, var. horridus, Kirchn.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..
,, obliquus (Turp.), Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..
Ankistrodesmus falcatus (Corda), Ralfs,	..	..	..	..	c	..	..	..	..	r	..	..	..	rrr	rr	r	×	..	..
,, ,, var. acicularis, (A. Br.), G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	rr	..	×	..	..
,, ,, var. mirabilis, G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..
,, ,, var. spiralis (Turn.), G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..
,, Pfitzeri (Schröder), G. S. West,	..	..	..	..	..	..	..	r	rr	..	..	..	rrr	..	..	..	..	×	..
,, biplex (Reinsch), G. S. West,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..
Selenastrum gracile, Reinsch,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..
Kirchneriella obesa (West), Schmidle,	..	rr	r	..	..	..	..	..	rr	..	..	..	r	rr	rr	..	..	×	..
Closteriopsis longissima, Lemm.,	..	..	..	..	..	..	..	..	rr	rr	..	..	r	..	r	rr	..	×	..
Oocystis solitaria, Wittr.,	..	..	..	..	..	rr	..	rr	..	..	..	..	..	..	rrr	rr	×	..	..
,, parva, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..
,, Marssonii, Lemm.,	..	..	..	..	..	..	..	rr	r	..	..	..	..	..	rr	..	..	×	..
,, lacustris, Chodat,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..
Nephrocytium Agardhianum, Näg.,	..	rr	..	..	..	rr	..	..	..	..	..	..	rrr	..	rr	rr	×	..	..
,, lunatum, West,	..	..	..	..	..	..	..	..	rrr	..	..	..	c	..	..	..	..	×	..
Tetraëdron enorme (Ralfs), Hansg.,	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, minimum (A. Br.), Hansg.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..
Golenkinia paucispinosa, W. & G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..
Richteriella botryoides (Schmidle), Lemm. forma quadriseta (Lemm.) Chodat,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
Dictyosphærium pulchellum, Wood,	..	..	rr	..	..	..	..	..	rr	c	r	rr	r	..	r	rr	..	×	..
Botryococcus Braunii, Kütz.,	..	..	..	..	..	..	c	r	c	c	rr	r	c	rrr	c	r	×	×	..
Ineffigiata neglecta, W. & G. S. West,	..	..	..	..	r	..	rr	rr	rr	..	rrr	rr	..	..	r	rr	×	×	..

TABLE OF PHYTOPLANKTON—*continued.*

Species.	Mayo.				Galway.					Kerry.							
	Lough Conn.	Lough Cullin.	Lough Keel, Achill Island.	Lough Acorrymore, Achill Island.	Small lakes between Clifden and Roundstone. I.	Small lakes between Clifden and Roundstone. II.	Small lakes between Clifden and Roundstone. III.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.	Lough Beg, Londonderry.	West of Scotland.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chlorophyceæ—*continued.*																	
Sphærocystis Schroeteri, Chodat,	rr	..	c	..	..	..	..	r	c	ccc	ccc	rrr	rr	c	c	..	×
Gloeocystis gigas (Kütz.), Lagerh.,	..	..	..	..	cc	..	c	..	..	rr	rr	..	r	..	r	rr	×
,, ,, var. planctonicus, var. n.,	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..	..
,, vesiculosa, Näg.,	..	..	..	..	c	..	..	..	..	..	..	..	..	..	..	..	×
,, infusionum (Schrank), W. & G. S. West,	rr	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..	×
Heterokontæ.																	
Askenasyella conferta, nob.,	..	..	..	..	..	..	rr	..	..	rrr	r	..	..	..	r	..	×
Oodesmus Doederleinii, Schmidle,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	×
Chlorobotrys regularis (West), Bohlin,	..	..	..	..	..	..	..	..	rrr	..	..	rr	..	..	rr	..	..
Ophiocytium parvulum (Perty), A. Br.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	×
Bacillarieæ.																	
Melosira varians, Ag.	cc	..	..	..	..	..	..	..	r	..	..	..	..	..	r	r	..
,, arenaria, Moore,	..	c	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..
,, granulata (Ehrenb.), Ralfs,	r	..	..	..	..	..	..	..	..	..	..	..	..	r	rr	..	×
,, crenulata, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	rr	..
,, ,, var. tenuis (Kütz.), Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..
Cyclotella compta, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	c	cc	rr	..	×
,, ,, var. affinis, Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..
,, operculata, Kütz.,	..	..	..	..	..	..	..	..	..	c	c	..	..	..	..	..	×
,, Meneghiniana, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	×
,, Kützingiana, Chauvin,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..
,, Schroeteri, Lemm.,	..	..	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..
Coscinodiscus lacustris, Grun.,	rr	r	..	..	..	..	..	..	r	..	..	..	..	..	cc	c	..
Stephanodiscus Astræa (Ehrenb.), Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
,, Hantzschii, Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
Rhizosolenia longiseta, Zach.,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	×
,, morsa, sp. n.,	..	..	..	..	..	..	..	..	..	c	c	..	cc	..	..	..	×
Tetracyclus lacustris, Ralfs,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	×
Tabellaria fenestrata (Lyngb.), Kütz.,	c	cc	..	rr	..	..	..	..	..	cc	ccc	ccc	r	rr	..	..	×
,, ,, var. asterionelloides, Grun.,	..	..	..	..	r	..	c	..	rrr	..	r	rr	r	ccc	ccc	ccc	×
,, flocculosa (Roth), Kütz.,	..	..	c	r	c	..	..	..	r	r	..	r	rr	r	..	..	×
Denticula tenuis, Kütz.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	rr	..
Meridion circulare (Grev.), Ag.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
Diatoma elongatum, Ag.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	r	..	×
[illegible] (Ag.), v. ii.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

,, Grotoniensis (A. M. Edw.), Kitton,	c	c	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	×
,, construens (Ehrenb.), Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	rrr	×
Synedra Ulna (Nitzsch.), Ehrenb.,	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	r	..	×
,, ,, var. longissima (W. Sm.), Brun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..
,, ,, var. splendens (Kütz.), Brun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
,, pulchella, Kütz.,	..	..	..	..	..	..	..	..	..	rr	..	..	..	r	..	..	..	×
,, Acus (Kütz.), Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	×
,, ,, var. angustissima, Grun.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..
,, ,, var. delicatissima (W. Sm.), V.H.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
,, radians (Kütz.), Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
,, revaliensis, Lemm.,	r	r	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, Lemmermanni, sp. n.,	c	r	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..	..
Asterionella formosa, Hass.,	ccc	ccc	r	..	..	..	..	..	cc	c	..	..	..	ccc	c	r	..	×
,, gracillima, Heib.,	c	..	..	..	..	..	..	..	c	..	cc	..	c	..	rr	..	..	×
Eunotia lunaris (Ehrenb.), Grun.,	..	..	rr	rr	..	..	rr	..	..	..	..	rr	..	..	..	..	..	×
,, pectinalis (Kütz.), Rabenh.,	..	..	c	c	rr	..	..	..	..	..	..	..	..	..	..	..	..	×
Achnanthes flexella (Kütz.), Bréb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..
Cocconeis Placentula, Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..
,, Pediculus, Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
Navicula major, Kütz.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	×
,, viridis, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	×
,, radiosa, Kütz.,	..	..	c	..	..	rr	r	..	rr	rrr	..	..	..	..	..	..	..	×
,, exilis, Grun.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..
Vanheurckia rhomboides (Ehrenb.), Bréb., var Saxonica (Rabenh.), G. S. West	r	..	..	..	..	..	c	..	r	..	..	r	rr	..	..	..	..	×
Amphipleura pellucida, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	×
Gyrosigma attenuatum (Kütz.), Rabenh.,	rr	r	..	..	..	..	..	..	r	..	..	..	..	..	rrr	rrr	..	..
,, Spencerii (Queck.), O. K.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	rr	..	..
Gomphonema geminatum (Lyngb.), Ag.,	rr	..	..	..	..	..	..	..	rr	rr	..	..	r	..	..	..	..	×
,, intricatum, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	×
Cocconema lanceolatum, Ehrenb.,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	×
,, cymbiforme, Ehrenb.,	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	×
,, cæspitosum (Kütz.), G. S. West,	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..
Amphora ovalis, Kütz.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	rrr	..	×
Epithemia turgida (Ehrenb.), Kutz.,	rrr	..	..	..	..	..	..	..	rr	..	..	..	..	r	rr	..	..	×
,, gibba, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
Nitzschia sigmoidea (Ehrenb.), W. Sm.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	rrr	rr	..	×
,, linearis (Ag.), W. Sm.,	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	×
,, Palea (Kütz.), W. Sm.,	rr	..	..	..	r	..	..	..	r	rr	..	r	..	..	r	..	..	×
,, dissipata (Kütz.), Grun., var. acuta, V. H.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, acicularis, W. Sm.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	rr	..	..	..
Surirella biseriata, Bréb.,	ccc	r	..	..	rr	..	..	..	c	..	..	..	..	rrr	c	c	..	×
,, robusta, Ehrenb.,	rr	..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	×
,, ,, var. splendida (Ehrenb.), V. H.,	r	rr	..	..	r	..	..	..	c	..	rr	..	..	rr	c	c	..	×
,, spiralis, Kütz.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..
,, turgida, W. Sm.,	r	rr	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..
,, ovalis, Bréb., var. ovata (Kütz.), V. H.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..
Cymatopleura Solea (Bréb.), W. Sm.,	r	rr	..	..	..	..	..	..	c	..	..	..	..	..	r	..	..	×
,, elliptica (Bréb.), W. Sm.,	c	r	..	..	..	..	..	..	c	..	..	..	..	..	r	..	..	×
,, ,, var. Hibernica (W. Sm.), V. H.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	r	..	..
,, ,, var. rhomboides, Grun.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..
Campylodiscus Hibernicus, Ehrenb.,	rr	..	..	..	.	..	..	..	rrr	..	..	..	..	..	rrr	rrr	..	..

Myxophyceæ.

Stigonema minutum, Hass.,	..	..	..	..	..	cc	c	..	..	..	..	..	..	..	..	..	..	×
Anabæna circinalis (Kütz.), Rabenh.,	r	c	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	×
,, ,, var. tenuis, var. n.,	..	..	..	..	..	..	..	cc	..	..	..	..	..	..	..	..	..	..
,, Flos-aquæ (Lyngb.), Bréb.,	rr	..	..	..	c	..	c	..	..	r	r	rrr	c	..	c	r	×	
,, Lemmermanni, Richter,	..	ccc	..	..	..	..	..	..	..	..	..	..	..	..	c	..	..	
Lyngbya Martensiana, Menegh.,	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	

TABLE OF PHYTOPLANKTON—*continued.*

Species.	Mayo.				Galway.					Kerry.							
	Lough Conn.	Lough Cullin.	Lough Keel, Achill Island.	Lough Acorrymore, Achill Island.	Small lakes between Clifden and Roundstone. I.	II.	III.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.	Lough Beg, Londonderry.	West of Scotland.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Myxophyceæ—*continued.*																	
Lyngbya limnetica, Lemm.,	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	rr	..	×
,, Kützingii, Schmidle, var. distincta (Nordst.), Lemm.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
Phormidium tenue (Menegh.), Gomont,	..	..	..	rr	..	..	..	..	r	..	..	..	..	..	r	..	..
Oscillatoria tenuis, Ag.,	c	r	..	..	..	..	..	..	..	..	..	..	,,	r	r	..	×
,, limosa, Ag..	..	..	..	..	..	..	..	rr	..	..	r	..	..	..	..	r	..
,, Agardhii, Gomont,	r	..	..	..	..	..	..	..	c	..	..	..	..	cc	..	..	..
Aphanothece saxicola, Näg.,	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..
,, clathrata, sp. n.,	..	..	..	..	..	..	..	..	r	..	..	..	..	..	c	..	..
Gloeothece linearis, Näg.,	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	×
Dactylococcopsis rhaphidioides, Hansg.,	..	..	..	..	..	..	..	..	..	rrr	..	rr	rr	..	rr	..	..
Merismopedia glauca (Ehrenb.), Näg.,	r	..	..	..	r	..	..	..	r	r	..	..	r	..	..	..	×
,, æruginea, Bréb.,	..	..	..	..	..	..	..	..	..	..	r	..	..	..	..	..	×
,, tenuissima, Lemm.,	..	..	..	..	rr	..	..	..	..	..	rr	..	..	..	rrr	..	..
Gomphosphæria aponina, Kütz.,	..	..	r	..	..	..	..	..	c	..	..	..	..	..	rrr	rr	..
,, lacustris, Chodat,	r	rr	..	..	c	rr	..	r	ccc	..	c	..	..	..	cc	c	×
Coelosphaerium Kützingianum, Näg.,	cc	c	..	..	..	..	..	c	r	rr	r	rrr	..	c	cc	r	×
,, Nägelianum, Unger,	..	..	..	..	..	..	..	c	r	..	rr	rrr	r	..	r	..	×
,, minutissimum, Lemm.,	..	..	..	..	..	..	r	..		..	..	..	r	..	rr	rr	×
,, natans, Lemm.,	rr	..	..	..	..	..	..	..	r	rr	..	..	rr	..	..	..	..
Microcystis incerta, Lemm.,	..	..	r	..	c	..	..	..	..	..	..	..	rrr	..	..	..	×
,, prasina (Wittr.), Lemm.,	..	rr	..	..	..	rr	..	..	..	..	..	rr	..	..	rr	rrr	..
,, stagnalis, Lemm.,	..	rr	..	..	..	..	..	..	r	..	..	..	..	..	c	rr	×
,, æruginosa (Kütz.), G. S. West,	..	r	..	..	..	..	..	..	..	..	..	..	..	..	c	r	..
,, roseo-persicinus (Kütz.), G. S. West,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..
Chroococcus limneticus, Lemm.,	r	r	c	..	..	..	..	rrr	rrr	..	..	..	..	..	r	c	×
,, ,, var. subsalsus, Lemm.,	..	..	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..
,, cohærens (Bréb.), Näg.,	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	×
,, helveticus, Näg.,	..	c	..	..	..	..	..	..	c	..	..	..	..	..	..	..	..
,, minimus (v. Keissler), Lemm.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..
,, turgidus (Kütz.), Näg.,	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..

Note.—The *Volvox aureus* Ehrenb. of the above list was originally recorded as *V. globator* Ehrenb. (*vide* Trans. Roy. Irish Acad., vol. xxxii., sect. B, part. i., 1902, p. 8); *Oocystis Marssonii* Lemm. was recorded as *O. crassa* Wittr. (l. c. p. 9); *Closteriopsis longissima* Lemm. was erroneously placed as *Rhaphidium longissimum* Schröder (l. c. p. 9); *Aphanothece clathrata* sp. n. was recorded as *A. nidulans* Richter (l. c. p. 9); and *Chroococcus minimus* (v. Keissler) Lemm. was recorded as *Chr. minor* (Kütz.) Näg. (l. c. p. 9).

PERIDINIALES.

In the determination of these organisms, which are abundant in some of the Irish loughs, we have to express our indebtedness to Mr. E. Lemmermann, of Bremen. He very kindly examined material from nine of the loughs, and reported upon the Peridiniales which he observed. One of them is a new variety which he has named *Gymnodinium paradoxum* Schill. var. *major*.

As in the Scottish plankton the most abundant of the Peridinieæ is *Ceratium hirundinella* O. F. M., and this organism is subject to more variation in the west of Ireland than has been recorded from elsewhere. This we have illustrated by a number of figures.

The table on p. 92 represents the species observed.

The following species are of special interest:—

1. GYMNODINIUM PARADOXUM Schilling in Flora, 1891, p. 59 (sep.), t. 3, f. 13.

Var. MAJOR Lemm., var. n.

Cellulæ ovales, 66–75μ longæ et 61–67μ latæ.

Hab.—Lough Currane, Kerry.

The typical form is nearly globular in shape, and averages about 34·5μ by 36·8μ.

2. GYMNODINIUM sp.

The specimens had been preserved in 3 per cent. formalin, but were useless for purposes of determination. The cells were embedded in a very wide gelatinous envelope such as occurs in *G. fuscum* (Ehrenb.) Stein and *G. Zachariasi* Lemm.

Hab.—Loughs Caragh and Derriana, Kerry.

SPECIES.	MAYO.				GALWAY.					KERRY.							
	Lough Conn.	Lough Cullin.	Lough Keel, Achill Island.	Lough Acorrymore, Achill Island.	Small Lakes between Clifden and Roundstone. I.	II.	III.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.	Lough Beg, Londonderry.	West of Scotland.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Gymnodinieæ.																	
Gymnodinium paradoxum, Schill., var. major, Lemm.,											×						
,, sp., ...										×		×					
Peridinieæ.																	
Glenodinium pulvisculus (Ehrenb.), Stein, . .															×		×
Ceratium cornutum (Ehrenb.), Clap. et Lachm., .					×		×		×								
,, hirundinella, O. F. Müller, . . .	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Peridinium bipes, Stein, ...										×							
,, cinctum, Ehrenb., ...								×							×	×	
,, tabulatum (Ehrenb.), Clap. et Lachm., .															×	×	×
,, Willei, Huitfeldt-Kaas., . . .															×		×
,, alatum, Garbini, ...								×		×	×	×		×			×
,, limbatum (Stokes), Lemm., . . .					×												

3. PERIDINIUM LIMBATUM (Stokes) Lemm. in Hedwigia, 1900, xxxix., p. 120. *Protoperidinium limbatum* Stokes in Proc. Trenton Nat. Hist. Soc. 1888, p. 14 1, t. 4, f. 1.

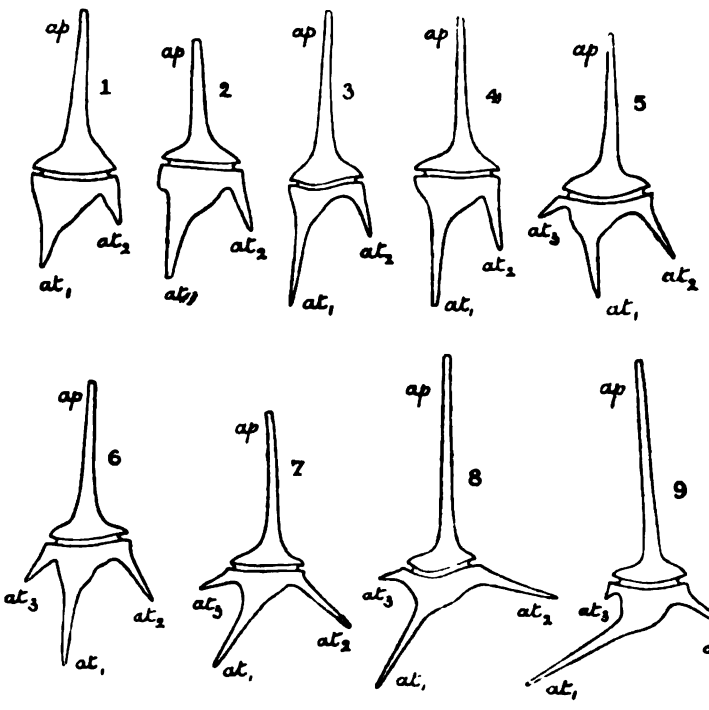
Length (with short horns), 90μ; breadth, 65μ.

Hab.—Small lake between Clifden and Roundstone, Galway.

This species is of particular interest, as there are no other records since its original discovery in the United States.

4. CERATIUM HIRUNDINELLA O. F. Müller.

The abundance and variation of this organism is one of the most striking features of the freshwater plankton of British and Irish lakes. We have noticed greater diversity of form in the Irish specimens than occurred amongst those of the west of Scotland or those of the Orkneys and Shetlands. The principal variations are in the length of the horns and the amount of their divergence; and it is not uncommon to have two, or even three, distinct forms in the plankton of one lake. Lemmermann figured a large number of different forms from the plankton of the Swedish lakes (*vide* Lemm. in Archiv. f. Bot. utgifv. af K. Sv. Vet.—Akad. Bd. 2, 1904, no. 2, t. 2, f. 1–49) and we figured four of the most widely divergent forms from the Scottish plankton (*vide* W. & G. S. West in Trans. Roy. Soc. Edinb., vol. xli., part iii., 1905, p. 494 cum fig. xylogr. 1).



FIGS. 1–9. *Ceratium hirundinella* O.F.M. All × 200.

1, from Lough Neagh; 2, from Lough Corrib; 3, from Lough Caragh; 4, from Lough Currane; 5, from Lough Acorrymore; 6, from small lake between Clifden and Roundstone (I.); 7, from small lake between Clifden and Roundstone (III.); 8 and 9, from small lake between Clifden and Roundstone (II.) *ap*. apical horn; at_1, at_2, and at_3, the three antapical horns.

Lemmermann has compiled the following Table of measurements :—

Locality.	Length of Apical Horn.	Length of 1st Antapical Horn.	Length of 2nd Antapical Horn.	Length of 3rd Antapical Horn.	Total Length of Body.
Lough Cullin, . . .	120–131·2 μ	86·2–112·5 μ	48·7–101·2 μ	·9–18·7 μ	214·2–237·7 μ
Small lake (I), between Clifden and Roundstone, . . .	127·5–138·7 μ	90–93·7 μ	56·2–60 μ	22·5–37·5 μ	219–233·9 μ
Lough Mawmeen, . .	97·5–116·2 μ	67·5–108·7 μ	41·2–67·5 μ	11·2–37·2 μ	169–222·5 μ
Lough Corrib, . . .	48·7–93·7 μ 112·5–113·7 μ	63·7–75 μ 93·7–97·5 μ	30–45 μ 52·5–63·7 μ	0 15–48·7 μ	144–162·7 μ 207·5–219 μ
Lough Caragh, . .	131–150 μ	90–109 μ	37·5–52·5 μ	0	222·5–260·5 μ
Lough Currane, . .	127·5–187·5 μ	82–108·5 μ	32·5–52·5 μ	0	211–286·5 μ
Lough Derriana, . .	142·5–146·2 μ	101·2–105 μ	45–48·7 μ	0	245·2–252·7 μ
Lough Larne, . . .	120–131·2 μ 120–131·2 μ	78·7–90 μ 82·5–86 μ	37·5–48·7 μ 41·2–48·7 μ	15–22·5 μ 0	207·7–222·7 μ 207·5–215·2 μ
Lough Neagh, . . .	101·2–131·2 μ 127·5–135 μ	75–101·2 μ 75–82·5 μ	41·2–45 μ 37·5–41·2 μ	7·5–22·5 μ 0	177·7–234 μ 204–219 μ

In many of the forms the third antapical horn is absent (figs. 1–4), and the variability in the amount of divergence of the antapical horns is well shown in figs. 4–9.

Fig. 9 exhibits a bending to one side of the first antapical horn which we have not observed from any other locality.

Protozoa, Rotifera, and Crustacea.

The following list of animals found in the plankton of the Irish lakes must be regarded as very incomplete, largely because the material was not examined in the living state. For the determination and verification of most of these records we have to thank Mr. E. Lemmermann, of Bremen.

Species.	Small Lakes between Clifden and Roundstone.		Lough Cullin.	Lough Mawmeen.	Lough Corrib.	Lough Caragh.	Lough Currane.	Lough Derriana.	Lough Guitane.	Lough Leane.	Lough Neagh.
	I.	II.									
Flagellata.											
Bicoeca lacustris, J. Cl., var. longipes, Zach.,							×	×			
Diplosigopsis frequentissima (Zach.), Lemm.,			×		×	×	×				
Mallomonas acaroides, Perty,			×		×		×			×	
,, caudata, Iwanoff,						×	×				
,, producta (Zach.), Iwanoff,	×										
Cryptomonas erosa, Ehrenb.,											×
Lepocinclis ovum (Ehrenb.), Lemm., var. punctato-striatum, Lemm.,											×
Euglena viridis, Ehrenb.,											×
Ciliata.											
Vorticella, sp.,			×	×	×						
Tintinnidium fluviatile, Stein,										×	
Rhizopoda.											
Arcella vulgaris, Ehrenb.,		×	×		×				×		
,, discoides, Ehrenb.,					×						
Nebela flabellulum, Leidy,		×									
Cyphoderia ampulla (Ehrenb.), Leidy,					×						
Rotifera.											
Conochilus unicornis, Rouss.,					×	×		×		×	
Asplanchna priodonta, Gosse,										×	×
Polyarthra platyptera, Ehrenb.,	×	×	×	×	×	×	×		×	×	
Triarthra longiseta, Ehrenb.,										×	
Pompholyx sulcata, Hudson,				×	×						
Anuræa aculeata, Ehrenb.,											×
,, cochlearis, Gosse,	×	×	×	×	×	×	×	×	×	×	×
Notholca longispina, Kellicot,	×	×	×	×	×	×	×	×	×	×	×
Cladocera.											
Daphnia galeata, Sars,										×	
Diaphanosoma brachyurum (Liév.), Sars,	×					×					×
Sida crystallina, O. F. M.,				×							
Holopedium gibberum, Zaddach,					×	×					
Polyphemus pediculus, de Geer,						×				×	
Ceriodaphnia pulchella, Sars,						×					
Bosmina longirostris, O. F. M.,			×			×	×	×		×	×
,, cornuta, Jur.,			×			×				×	×
Chydorus sphæricus, O. F. M.,											×
Copepoda.											
Diaptomus graciloides, Sars,	×				×	×				×	×
Cyclops, sp.,							×			×	×
Nauplii,					×	×			×	×	

III. Systematic Account of the more Important Algæ of the Plankton.

This section deals specifically with those Algæ of the plankton deserving of special mention, either for their abundance or rarity, or for some peculiarity which has hitherto escaped observation. The five following species we consider to be new; and they are here described for the first time:—*Cosmarium Corribense*, *Staurastrum dorsidentiferum*, *Rhizosolenia morsa*, *Synedra Lemmermanni*, and *Aphanothece clathrata*.

The small parasitic fungus which occurs in *Pleurotænium Ehrenbergii* (Ralfs) De Bary is of very great interest, and the curious forms of *Eudorina elegans* Ehrenb. described from Lough Mawmeen, Galway, may assist in throwing some light on the true nature of the supposed genus *Pleodorina*. Three previously undescribed varieties are *Microspora amœna* (Kütz.) Rabenh. var. *irregularis*, *Staurastrum furcigerum* Bréb. var. *reductum*, and *Glœocystis gigas* (Kütz.) Lagerh. var. *planctonicus*.

Class CHLOROPHYCEÆ.

Order **Microsporales.**

Family Microsporaceæ.

Genus *Microspora* Thur., 1850; em. Lagerh., 1888.

1. Microspora amœna (Kütz.) Rabenh. Flor. Europ. Algar. III., 1868, p. 321; Lagerh. in Berichte Deutsch. Bot. Gesellsch. v., 1887, p. 417; Hazen in Mem. Torr. Bot. Club, xi., 1902, p. 170, t. 23, f. 1. *Conferva amœna* Kütz. Spec. Algar. 1849, p. 372.

Var. irregularis var. n. (Pl. x., figs. 5–6).

Var. membrana cellularum multe crassiori, filis externe corrugatis et irregulariter lamellosis. Crass. fil. 24–30μ; crass. membr. cell. 4–7μ.

Hab.—Loughs Keel and Acorrymore, Achill Is., Mayo.

This variety is distinguished from typical *Microspora amœna* by the slightly greater diameter of the filaments, and by the increased thickness and greater irregularity of the cell-walls. The latter are evidently lamellose, but the lamellæ are very irregular, in consequence of which the exterior of the filament exhibits a corrugated and sometimes a frayed appearance, being strikingly reminiscent of the "ocreate" character of the sheaths of some species of *Scytonema*. We have observed this variety in quantity from the Scottish plankton, and have also collected it in a number of widely separated localities in the British Islands, notably in abundance from near Lerwick, Shetland Is., and from the New Forest, Hants. The irregularity of the cell-wall is somewhat variable, and in some filaments the cell-walls are intermediate in character between those of typical *M. amœna* and those of var. *irregularis*. In its dimensions, and also in the shortness of its cells, the var. *irregularis* more nearly agrees with *M. crassior* (Hansg.) Hazen; but we think that Wille was quite right in regarding the latter as *M. amœna* forma *crassior*.

Order **Chætophorales**.

Family CHÆTOPHORACEÆ.

Genus *Myxonema* Fries, 1825.

2. MYXONEMA SUBSECUNDUM (Kütz.) Hazen in Mem. Torr. Bot. Club, 1902, vol. xi., no. 2, p. 207. *Conferva subsecunda* Kütz., 1836. *Stigeoclonium subsecundum* Kütz. Phycolog. Gener. 1843, p. 253; Rabenh. Flor. Europ. Algar. III., 1868, p. 376.

The following is a short description of the plants observed from Ireland. In none of the branches were there any short cells noticed; otherwise the species agrees with the published descriptions, and with the dimensions, of *M. subsecundum*.

Filaments free-floating and elongated, 12–16μ in diameter, very sparsely branched; branches never opposite, elongated and gradually attenuated towards the apex; cells cylindrical, $2\frac{1}{2}$–10 times longer than

their diameter; cells of main filaments from which branches are given off frequently tumid, cells of branches generally longer than those of the principal filaments, 3·5–7μ in diameter.

One or two short branches were noticed which were unseptate and therefore unicellular (*vide* Pl. x., fig. 3). From many of the cells of the basal and older parts of the plants zoogonidia had escaped (Pl. x., fig. 4).

Hab.—Lough Mawmeen, between Clifden and Roundstone, Galway.

Order **Conjugatæ.**

Family Desmidiaceæ.

Genus *Gonatozygon* De Bary.

3. Gonatozygon Kinahani (Arch.) Rabenh. Flor. Europ. Algar. III., 1868, p. 156; W. & G. S. West, Brit. Desm. I., 1904, p. 35, t. 2, f. 1–3.

Long. cell. usque ad 450μ; lat. cell. 12–14μ.

Hab.—Lough Mawmeen, between Clifden and Roundstone, Galway.

The specimens observed were among the best we have seen, and the cells were attached to form long filaments.

4. Gonatozygon aculeatum Hastings in Amer. Month. Micr. Journ., 1892, p. 29; Johns. in Bull. Torr. Bot. Club, 1895, vol. xxii., no. 7, p. 291, t. 239, f. 9. *G. aculeatum* forma *minor* W. & G. S. West in Trans. Linn. Soc. Bot. ser. 2, v., 1896, p. 230, t. 12, figs. 1, 2.

Lat. cell. in med. sine acul. 11μ, ad apic. 12·5μ; long. acul. 7–8μ.

Hab.—Small lake between Clifden and Roundstone, Galway.

We have also observed this rare species from the Scottish plankton (*vide* W. & G. S. West in Trans. Roy. Soc. Edin., vol. xli., part iii., 1905, p. 498, t. 6, f. 2).

Genus *Pleurotænium* Näg.

5. Pleurotænium Ehrenbergii (Bréb.) De Bary, Conj. 1858, p. 75; W. & G. S. West, Brit. Desm. I., 1904, p. 205, t. 29, f. 9–11; t. 30, f. 1.

In a collection of plankton from one of the small lakes between Clifden and Roundstone, Galway, we observed a specimen of *Pleurotænium Ehrenbergii* which had been attacked by a parasitic fungus. We have observed the same parasite on a previous occasion in an individual of the same species of *Pleurotænium*. This was from the plankton of Loch Fadaghoda, Lewis, Outer Hebrides. The parasite is of great interest, as it was this very fungus, in, moreover, the same species of Desmid, which caused Archer (Quart. Journ. Micr. Sci. viii., 1860, pp. 227–234, t. 11, f. 1–4) to publish an account of what he supposed was zoospore-formation in the Desmidiaceæ. The fungus belongs to the Chytridiaceæ, and the tubular projection through which the gonidia are discharged, appears always to push its way to the exterior in the region of the isthmus at the junction of the two semicells. Archer noticed as many as three of these tubular extensions; but he was certainly in error when he wrote that "the tubular extensions are produced directly from an addition to the original cell-wall itself, and with which they are in absolute continuation." We have only seen two specimens of the parasite, both of which were preserved in formalin; and in each case the gonidia were clustered round the orifice of the tubular, neck-like extension. These gonidia were destitute of colour, and the cilia could not be detected. The parasite itself occupied both semicells of the host, the contents of which had disappeared except for a number of dark-brown granular masses of small size, which were attached to the outer surface of the cell-wall of the fungus. The tubular extension which passes out to the exterior, is a branch which is first closely adpressed to the main portion of the parasite, and which suddenly bends at right angles as it emerges at the isthmus. At the point of origin of this branch a septum was noticed dividing the endophytic fungus into two portions (Pl. XI., fig. 9).

Genus *Cosmarium* Corda, 1834.

6. COSMARIUM SUBARCTOUM (Lagerh.) Racib. in Rozpraw Wydz. matem.-przy. Akad. Umiej. Krakow. xxii., 1892, p. 385, t. 6, f. 24. *C. globosum* Buln. subsp. *subarctoum* Lagerh. in Wittr. & Nordst. Alg. Exsic. 1883, no. 567; Nordst. in Öfvers. af K. Vet.-Akad. Förh. 1885, no. 3, p. 9, t. 7, f. 5.

Long. 20–21·5μ; lat. 16–17μ; lat. isthm. 11–11·5μ.

Hab.—Loughs Caragh, Currane, and Guitane, Kerry.

This minute species occurred in considerable quantity in the plankton of the above-mentioned loughs. It is recognized by its relatively shallow constriction and its slightly flattened apices, these features distinguishing it from *C. bioculatum* Bréb. The specimens observed from the south-west of Ireland were very similar to those recorded from the Shetland Is., but the cell-wall was smooth.

7. COSMARIUM CORRIBENSE sp. n. (Pl. XI., figs. 20, 21).

C. parvum, circiter tam longum quam latum, subprofunde constrictum, sinu late aperto obtusangulo; semicellulæ cuneatæ, apice truncato pæne recto, angulis superioribus rotundatis, lateribus leviter convexis; a latere visæ subrotundatæ; a vertice visæ ellipticæ, polis obtuse conicis; membrana glabra; pyrenoidibus singulis.

Long. 22–24μ; lat. 19–24μ; lat. isthm. 11·5–12μ; crass. 12μ.

Hab.—Lough Corrib, Galway.

This species approaches very closely to *C. bicuneatum* (Gay) Nordst, but it is much larger, the angles of the semicells are more rounded, and the thickness is much greater. Another Desmid which is almost identical with *C. bicuneatum* in the form of its front view is *C. arctoum* Nordst. var. *tatricum* Racib. (in Pamietnik Wydz. Akad. Umiej. w Krakow. 1885, x., p. 78, t. 11, f. 6); but in side and vertical views it is much thicker. *C. Corribense* differs from Raciborski's variety in its much greater size, its deeper constriction, and the rounded angles of the semicells.

It should also be compared with *C. subaversum* Borge and *C. subarctoum* (Lagerh.) Racib.

8. COSMARIUM SUBTUMIDUM Nordst. in Wittr. & Nordst. Alg. Exsic. 1878, no. 172; 1889, fasc. 21, p. 44 cum fig. xylogr.

Var. KLEBSII (Gutw.) W. & G. S. West, Brit. Desm. II., 1905, p. 193, t. 63, f. 21–23. *C. Klebsii* Gutw., 1892.

Forma depressa, paullo latior quam longa (Pl. XI., fig. 22).

Long. 22–23μ; lat. 25–27μ; lat. isthm. 8–9μ; crass. 11·5μ.

Hab.—Lough Corrib, Galway.

Genus *Cosmocladium* Bréb., 1856.

9. COSMOCLADIUM SAXONICUM De Bary in Flora, 1865, pp. 321–329, t. 4, f. 1–3; Schröder in Berichte Deutsch. Botan. Gesellsch., 1900, xviii., pp. 15–23, t. 1.

Long. 25–27μ; lat. 19–20μ; lat. isthm. 6·5–7μ; crass. 13–15μ.

Hab.—Small lake, between Clifden and Roundstone, Galway.

This Desmid has been very well investigated by Schröder, and the Irish plants agreed with his figures in the method of attachment of the cells. The gelatinous threads were attached above and below the isthmus, and almost invariably on the broader face (front view) of the cells, so that the cells in a branched colony were generally presented for observation in the side view.

Genus *Xanthidium* Ehrenb., 1834.

10. XANTHIDIUM SUBHASTIFERUM West, in Journ. Linn. Soc., Bot. xxix., 1892, p. 166, t. 22, f. 4; l.c. xxxv., 1903, p. 540, t. 16, f. 4, 5.

This species occurred in all the loughs examined in Kerry, and was particularly abundant from Loughs Caragh, Currane, and Guitane. Some of them exhibit irregularities in the spines, such as the presence of a third incipient spine between the two lateral ones. Three of these abnormal individuals are figured on Pl. xi., figs. 13–15.

Long. 43–47μ; lat. sine spin. 44–49μ, cum spin. 64–71μ; lat. isthm. 13–14μ.

Genus *Staurastrum* Meyen, 1829.

11. STAURASTRUM DEJECTUM Bréb. in Menegh. Synops. Desm. 1840, p. 227; Ralfs, Brit. Desm. 1848, p. 121, t. 20, f. 5*a*.

Forma major, spinis validioribus. (Pl. xi., fig. 16).

Long. sine spin. 42μ; lat. sine spin. 48μ, cum spin. 80–85μ; lat. isthm. 11μ.

Hab.—Lough Corrib, Galway.

12. STAURASTRUM JACULIFERUM West in Journ. Linn. Soc., Bot. xxix., 1892, p. 172, t. 22, f. 14; l.c. xxxv, 1903, p. 543, t. 17, f. 1–4.

The forms of this species observed possessed very long spines. The direction of the spines was variable, and tri- and quadri-radiate semicells were often combined in the same plant (Pl. xi., figs. 17–19).

Long. sine spin. 20–22μ; lat. sine spin. 15–16μ; lat. cum spin. 60–78μ; lat. isthm. 6μ.

13. STAURASTRUM LUNATUM Ralfs, Brit. Desm. 1848, p. 124, t. 34, f. 12.

Var. PLANCTONICUM W. & G. S. West in Journ. Linn. Soc., Bot. xxxv., 1903, p. 546, t. 16, f. 11, 12.

This Desmid was general in most of the Irish lakes. It bears considerable resemblance to *St. lunatum* Ralfs forma *alpestris* Schmidle (in Oesterr. botan. Zeitschr. 1895–6, p. 24, t. 16, f. 27), but differs in the more attenuated angles of the semicells, which run directly into the spines, as well as in its uniform covering of granules.

14. STAURASTRUM DENTICULATUM (Näg.) Arch. in Pritch. Infus., 1861, p. 738. *Phycastrum denticulatum* Näg. Gatt. einz. Alg., 1849, p. 128, t. 8C, f. 3.

Long. 28–35μ; lat. 36–40μ; lat. isthm. 11.5–14μ. (Pl. xi., fig. 11).

Hab.—Lough Conn, Mayo. Loughs Caragh and Derriana, Kerry.

This species differs from *St. Avicula* Bréb. var. *subarcuatum* (Wolle) West in its proportionately greater breadth, in the two denticulations at the angles, and in the few regular rows of minute denticulations round the angles.

15. STAURASTRUM DORSIDENTIFERUM sp. n. (Pl. xi., fig. 10).

St. magnum, circiter 1½–plo latius quam longum (cum processibus), modice constrictum, sinu aperto et obtuso; semicellulæ cyathiformes et glabræ, apice plerumque recto et levissime sinuato, angulis in processus longos validos et subhorizontaliter dispositos productis, apicibus processuum quadridentatis, margine inferiori processus uniuscujusque crenulato, margine superiori crenulato et crenis medianis 3–6 (plerumque 5) acute dentatis; a vertice visæ triangulares, lateribus leviter convexis, angulis in processus longus productis, marginibus processuum undulatis.

Long. (max.) 75–79μ; lat. sine proc. circ. 48μ; lat. cum. proc. 108–120μ; lat. isthm. 18μ.

Hab.—Loughs Conn and Cullin, Mayo. Lough Corrib, Galway.

The direction of the processes in the front view is somewhat variable. In some specimens they are slightly upwardly divergent, but in the majority they are horizontally disposed. The number of teeth affixed to the crenations of the upper margin of the processes is also variable, even on the processes of the same plant.

It should be compared with *St. gracile* Ralfs and *St. Sebaldi* Reinsch.

16. STAURASTRUM FURCIGERUM Bréb. in Menegh. Synops. Desm., 1840, p. 226. *Didymocladon furcigerum* Ralfs, Brit. Desm., 1848, p. 144, t. 33, f. 12.

Var. REDUCTUM var. n. (Pl. XI., fig. 12).

Var. processibus multe brevioribus, processibus superioribus brevissimis; semicellulæ a vertice visæ triangulares, lateribus pæne rectis vel levissime convexis.

Long. 43μ; lat. cum proc. 54μ; lat. isthm. 21μ.

Hab.—Lough Corrib, Galway.

This variety is principally distinguished by the great reduction of the superior processes. We have noticed one semicell in which they were altogether suppressed.

Genus *Desmidium* Ag., 1824.

17. DESMIDIUM PSEUDOSTREPTONEMA W. & G. S. West in Trans. Linn. Soc., Bot., ser. 2, vi., 1902, p. 193, t. 22, f. 35–37.

Long. cell. 17–20μ; lat. 33–35μ; lat. isthm. 20–22μ; lat. apic. 14–15·5μ. (Pl. XI., fig. 23).

Hab.—Small lake, between Clifden and Roundstone, Galway.

This species has only previously been recorded from Ceylon, in which country both two-lobed and triangular forms occur. The Irish specimens were two-lobed in vertical view, and except for a slight increase in the breadth of the isthmus, they were exactly similar to those from Ceylon.

Order **Protococcoideæ**.

Family VOLVOCACEÆ.

Genus *Eudorina* Ehrenb., 1832.

18. EUDORINA ELEGANS Ehrenb., 1831; Cooke, Brit. Freshw. Alg., p. 65, t. 26.

We figure two rather interesting cœnobia of this Alga. (Pl. x., figs. 7 and 8), which were observed among an immense number of individuals in the plankton of Lough Mawmeen, Galway.

Some of the cells had remained relatively small, whereas others had reached the maximum size attainable by the vegetative cells of this organism. The arrangement of large and small cells appeared to be indiscriminate, one size of cell not being restricted to a definite part of the cœnobium. In one of the cœnobia several of the cells had more or less disintegrated. These two examples appear to lend support to Chodat's view that the species of *Pleodorina* Shaw should only be regarded as forms of *Eudorina elegans.*

Family CHARACIEÆ.

Genus *Characium* A. Br., 1849.

19. CHARACIUM DEBARYANUM (Reinsch) De Toni. *Dactylococcus Debaryanus* Reinsch.

Long. cell. 12–18μ; lat. cell. 7–9·5μ.

Hab.—Attached to *Cyclops* sp. in Lough Keel, Achill Is., Mayo.

This Alga is not uncommon, but we have never before seen it in such quantity, *all* the *Cyclops* in the collection being covered with it. The first divisions of the cell-contents prior to the formation of zoogonidia are curiously oblique, and not unlike the divisions which occur in *Dactylococcus* during the formation of autospores. Three other species of this genus occur attached to Entomostraca:—*Ch. groenlandicum* Richter, *Ch. limneticum* Lemm., and *Ch. Hookeri* (Reinsch) Hansg.

Family PROTOCOCCACEÆ.

Genus *Scenedesmus* Meyen, 1829.

20. SCENEDESMUS BIJUGATUS (Turp.) Kütz.

Forma ARCUATUS (Lemm.) nob. *Scenedesmus arcuatus* Lemm. in Plöner Forschungsberichten, vii., 1899, p. 17, t. 1, f. 2–4.

Long. cœnob. 32–44μ; long. cell. 14–18μ; lat. cell. 7–9·5μ (Pl. x., figs. 12–14).

Hab.—Lough Corrib, Galway.

We do not think there is sufficient justification for the separation of this form as a distinct species.

Genus *Closteriopsis* Lemm., 1899.

21. CLOSTERIOPSIS LONGISSIMA Lemm. 'Das Phytoplankton sächs. Teiche,' Plöner Forschungsberichten, vii., 1899, p. 29, t. 2, f. 36–38. *Closterium pronum* Bréb. var. *longissimum* Lemm.

Long. 370–527μ; lat. 5–6μ (Pl. x., figs. 17–19).

Hab.—Lough Neagh. Loughs Mawmeen and Corrib, Galway. Loughs Derriana and Leane, Kerry.

Numerous specimens of this interesting Alga were observed, and in the material from Lough Leane three or four individuals were often attached to form a group. Most of the specimens were quite straight, but a few were much bent.

The Alga we recorded from the plankton of Lough Neagh under the erroneous name of "*Rhaphidium longissimum* Schröder" (*vide* Trans. Roy. Irish Acad. xxxii., sect. B., 1902, p. 65, t. 1, f. 19), is a form of *Closteriopsis longissima*. The Alga is also known from the Orkney Is., and a variety of it—var. *tropicum* W. & G. S. West—from the Shetland Is.

Closteriopsis longissima approaches very near to some of the long and narrow species of *Closterium*, especially to *Cl. aciculare* T. West var. *subpronum* W. & G. S. West. It only differs from this Desmid in the slightly narrower extremities and in the uninterrupted chloroplast. The latter is not subdivided in the median part of the cell, and it generally extends, occasionally with slight interruptions, well into the elongated extremities of the cell. The chloroplasts do not extend into the narrow extremities of *Closterium aciculare* var. *subpronum*, the elongated terminal parts being clear and transparent, and in the living plant containing a single moving corpuscle. This *Closterium* occurs principally in large ponds and ditches, and is not infrequently found in the plankton of lakes. May not *Closteriopsis longissima* be a degenerate form of it?

Genus *Oocystis* Näg., 1845.

22. OOCYSTIS LACUSTRIS Chodat in Bull. de l'Herbier Boissier, 1897, p. 296; Algues Vertes de la Suisse, 1902, p. 190.

Long. colon. 43–60μ; long. cell. 14–22μ; lat. cell. 8–15μ.

Hab.—Lough Corrib, Galway.

We are not quite certain of the identification of this species. It was quite common, and the colonies were very variable in size, containing from 2 to 8 cells. The cells were elliptical and very faintly apiculate at the poles. Each cell contained one or two chloroplasts. It seems scarcely possible to separate *O. Marssonii* Lemm. (1899) from *O lacustris* Chod. (1897), as in each the cells possess one or two chloroplasts and are very slightly thickened at the poles. Both are near *O. crassa* Wittr. (1880), but the latter, so far as we have recognized the species, possesses from six to eight chloroplasts in each cell. Ostenfeld has apparently had the same difficulty in identifying a species of *Oocystis* from a lake in Iceland (*vide* Botanisk Tidsskrift, Bd. 26, 1904, p. 235).

Family PALMELLACEÆ.

Genus *Glœocystis* Näg., 1849.

23. GLŒOCYSTIS GIGAS (Kütz.) Lagerh.

Var. PLANCTONICUS var. n. (Pl. x., figs. 15, 16).

Var. cellulis tetraëdrice dispositis in coloniis mucosis libere natantibus.

Diam. cell. 7·5–12μ; diam. colon. 120–135μ.

Hab.—Small lake between Clifden and Roundstone, Galway.

Quite a number of colonies of this Alga were observed from the above locality, and the regular tetrahedral disposition of the cells was a very remarkable feature. In *Glœocystis gigas* the four daughter-cells which arise from one mother-cell are generally disposed in a tetrahedral manner, but we have never before seen this disposition maintained throughout the entire colony.

Class HETEROKONTÆ.

Order **Confervales.**

Family CHLOROTHECIACEÆ.

Genus *Askenasyella* Schmidle, 1902.

24. ASKENASYELLA CONFERTA nob. *Actinobotrys conferta* W. & G. S. West in Trans. Roy. Soc. Edin. xli, 1905, p. 508, t. 6, f. 17–19.

The genus we described as "*Actinobotrys*" (1905) must be regarded as synonymous with one described by Schmidle as *Askenasyella* (*vide* Hedwigia, 1902, pp. 154–157, cum fig. 1–3). The plants agree in the mucous, free-floating colonies, and in the radiating disposition of the cells, which possess parietal chromatophores without pyrenoids.

A. conferta nob. differs from *A. chlamydopus* Schmidle in the form of the cells (which are oblong, ellipsoid, or globose, and never pyriform), and in the more radiating character of the colonies. The cells are also more crowded, and they exhibit a reduction in size from the centre outwards. *A. conferta* is abundant in some of the Scottish plankton; and in the Irish plankton we have noticed it from a small lake between Clifden and Roundstone, Galway, from Loughs Caragh and Currane, Kerry, and from Lough Neagh.

Class BACILLARIEÆ.

Order **Centricæ.**

Family COSCINODISCACEÆ.

Genus *Cyclotella* Kütz., 1833.

25. CYCLOTELLA SCHRÖTERI Lemm. in Berichte Deutsch. Botan. Gesellsch. xviii., 1900, p. 30. *C. compta* (Ehrenb.) Kütz. var. *quadrijuncta* Schröter.

Hab.—Lough Corrib, Galway.

The cells were distantly held together in mucous tubes, forming colonies containing as many as twelve cells.

Family RHIZOSOLENIACEÆ.

Genus *Rhizosolenia* Ehrenb., 1858; em. Peragallo, 1892.

26. RHIZOSOLENIA LONGISETA Zach., 1897; Schröder in Berichte Deutsch. Botan. Gesselsch. xv., 1897, t. xvii., f. 2; t. xxv., f. 2.

This Diatom occurred sparingly in the plankton of Lough Corrib, Galway. It is known to occur in the Scottish plankton (Pl. xi., fig. 8).

27. RHIZOSOLENIA MORSA sp. n. (Pl. xi., figs. 5–7).

Rh. Eriensis H. L. Smith var. *morsa* W. & G. S. West in Trans. Roy. Soc. Edin. xli., part iii., 1905, p. 509, t. 6, f. 23.

Cellula ut visa aspectu valvulari anguste elliptica; ut visa aspectu cingulato (aspectu normali) elongata, lateribus rectis et parallelis, polis subito et oblique angustatis, marginibus partium angustatarum concavis, calyptra late conica cum lateribus concavis, seta subtile et longissima prædita.

Long. sine setis 100–165μ; lat. 12–22μ (a latere visa 4·6μ); long. set. 50–60μ.

Hab.—Loughs Caragh, Currane, and Guitane, Kerry.

This species occurred in abundance in the plankton of Loch Shiel, Inverness. It is distinguished from *Rh. Eriensis* H. L. Smith (*vide* Le Diatomiste, 1892, p. 109, t. 1, f. 19) by the angular extremities, the lateral margins of which are concave, and by the much thinner and longer setæ. This is now the fourth freshwater species of the genus.

Order **Pennatæ.**

Family FRAGILARIACEÆ.

Genus *Synedra* Ehrenb., 1831.

28. SYNEDRA LEMMERMANNI sp. n. (Pl. xi., figs. 1, 2).

Cellula ut visa aspectu valvulari linearis, angustissima et longissima, gradatim et gradatim angustior apices versus, apicibus levissime sed distincte inflatis; ut visa aspectu cingulato angustissime linearis, marginibus parallelis, polis truncatis. Striæ 10 in 10·3μ. Cellulæ libere natantes.

Long. 430–440μ; lat. ad med. (aspect. valv.) 3·3μ.

Hab.—Loughs Conn and Cullin, Mayo. Lough Corrib, Galway.

This species was frequent in the material from Lough Conn and Lough Corrib. It is distinguished from *S. Acus* (Kütz.) Grun., *S. Acus* var. *delicatissima* (W. Sm.) Grun., and *S. Acus* var. *angustissima* Grun. by its relatively much greater length and slightly coarser striæ. *S. Acus* var. *angustissima* occurred mixed with it in the material from L. Corrib, and is very much shorter, has much narrower apices, and a rather slight inflation in the middle. We give a figure of this variety for comparison (Pl. XI., figs. 3 and 4).

S. Ulna (Nitzsch) Ehrenb. var. *longissima* (W. Sm.) Brun. is a much stronger and coarser *Synedra*, with strongly capitate poles.

29. SYNEDRA REVALIENSIS Lemm. MSS.

Hab.—Loughs Conn and Cullin, Mayo.

This species occurs in radiating clusters and belongs to Lemmermann's subgenus *Belonastrum* (*vide* Berichte Deutsch. Botan. Gesellsch. xviii., 1900, p. 31). The valves are very narrow and about 170–180μ in length. Lemmermann has described the species as occurring in plankton from Russia, and an account of this plankton is soon to be published by Dr. G. Schneider of Helsingfors.

Class MYXOPHYCEÆ.

Order **Hormogoneæ.**

Family NOSTOCACEÆ.

Genus *Anabæna* Bory, 1822.

30. ANABÆNA CIRCINALIS (Kütz.) Rabenh., 1852; Born. et Flah. Revis. Nostoc. Hétérocyst., p. 230.

Cylindrospermum circinale Kütz., 1845. *Cyl. Hassallii* Kütz., 1849. *Anabæna Hassallii* (Kütz.) Wittr. in Wittr. & Nordst. Alg. Exsic. fasc. 21, p. 56.

Crass. cell. veget. 8–9·5μ. (Pl. VIII., no. vi. 1).

Hab.—Loughs Conn and Cullin, Mayo. Lough Corrib, Galway.

Var. TENUIS var. n. (Pl. VII., no. vi. 2).

Crass. cell. veget. 5·5–6μ.

Hab.—Lough Mawmeen, Galway.

The distinctions between *A. circinalis* and its var. *tenuis* are well shown by the two photographs, Pl. VII., no. vi. 2 and Pl. VIII., no. vi. 1.

31. Anabæna Lemmermanni Richter in Lemm. 'Das Phytoplankton einiger Ploner Seen,' Forschungsbericht aus der Biol. Station zu Plön, x. 1903, p. 153.

Hab.—Lough Cullin, Mayo.

The enormous abundance of the spores of this species, which occurred in floating masses, caused the plankton to assume a very dark green colour.

Family Oscillatoriaceæ.

Genus *Oscillatoria* Vauch., 1803.

32. Oscillatoria Agardhii Gomont, Monogr. des Oscillariées, 1893, p. 225.

Crass. trich. 5·3–6μ. (Pl. XI., fig. 28–30).

Hab.—Lough Conn, Mayo. Lough Corrib, Galway. Lough Leane, Kerry.

We take this opportunity of figuring this interesting species (Pl. XI., figs. 28–30).

Order **Coccogoneæ**.

Family Chroococcaceæ.

Genus *Aphanothece* Näg., 1849.

33. Aphanothece clathrata sp. n. (Pl. X., figs. 9–11).

A. thallo minuto, irregulari, libere natante inter algas varias planctonicas, conspicue et irregulariter clathrato; cellulis minutissimis, læte æruginosis, bacillariformibus, rectis vel leviter subcurvatis, confertissimis.

Diam. thall. 40–150μ; long. thall. 300–355μ; diam. cell. 0·6–0·7μ; long. cell. 3·7–4·5μ.

Hab.—Lough Neagh. Lough Corrib, Galway.

The only species approaching *A. clathrata* is *A. nidulans* Richter (in Wittr. & Nordst. Alg. Exsic. no. 694, 1884; in Hedwigia v, 1884), from

which it is distinguished by the well-defined and clathrate thallus, and by the smaller diameter of the cells, which are both longer and narrower.

We recorded this Alga from the plankton of Lough Neagh (*vide* Trans. Roy. Irish Acad., 1902, xxxii., pp. 9 and 76) under the name of *A. nidulans*, Richter; but we are now convinced of its specific distinctness.

Genus *Gomphosphæria* Kütz., 1836.

34. GOMPHOSPHÆRIA LACUSTRIS Chodat in Bull. de l'Herb. Bossier, vi., 1898, pp. 180–182, cum fig. 1.

Diam. colon. 28–76μ; diam. cell. 2–2·2μ. (Pl. XI., figs. 24–27).

Hab.—Loughs Conn and Cullin, Mayo. Small lakes between Clifden and Roundstone, and Loughs Mawmeen and Corrib, Galway. Lough Currane, Kerry. Lough Neagh. Lough Beg, Londonderry.

This Alga occurred in prodigious quantity in Lough Corrib, being the dominant feature of the plankton. In damaged colonies the radiating structure of the internal mucus can be readily observed (fig. 26), and not infrequently all the cells have become lost, and this mass of mucus is floating by itself (fig. 27).

Genus *Chroococcus* Näg., 1849.

35. CHROOCOCCUS LIMNETICUS Lemm. in Bot. Centralbl., 1898, Bd. 76, p. 153; Forschungsber. der Biol. Stat. Plön, vii., t. 1, f. 22, 23.

Var. SUBSALSUS Lemm. Forschungsber. der Biol. Stat. Plön, viii., p. 84; Archiv für Botan. utgifv. af. K. Sv. Vet.—Akad. Bd. 2, no. 2, 1904, p. 101, t. 1, f. 9.

Hab.—Lough Corrib, Galway.

36. CHROOCOCCUS MINIMUS (v. Keissler) Lemm. l. c. p. 102. *Ch. minutus* var. *minimus* v. Keissler in Verhandl. der zool.-bot. Gesellsch. Wien, 1901, p. 394, f. 1, 2.

Hab.—Lough Neagh.

We have previously recorded this species under the name of "*Ch. minor* (Kütz.) Näg.," a blue green Alga which most probably should be relegated to the genus *Aphanocapsa*.

EXPLANATION OF PLATES.

PLATE VI.

Photomicrographs of plankton from Lough Neagh. All × 100.

I. 1, *Anuræa cochlearis*; 2, *Pediastrum duplex*; 3, *Surirella biseriata*; 4, Fragment of *Ceratium hirundinella.*

II. 1 and 2, *Pediastrum duplex*; 3, *Closterium aciculare* var. *subpronum*; 4, *Surirella robusta* var. *splendida*; 5, *Gomphosphæria lacustris*; 6, *Peridinium cinctum.*

III. 1 and 2, *Anuræa cochlearis*; 3 and 11, *Peridinium cinctum*; 4, *Staurastrum paradoxum* var. *longipes*; 5, *Pediastrum duplex*; 6, *Gomphosphæria lacustris*; 7 and 8, *Tabellaria fenestrata* var. *asterionelloides*; 9, *Coscinodiscus lacustris*; 10, *Surirella robusta* var. *splendida.*

IV. 1, *Peridinium cinctum*; 2, *Staurastrum pelagicum*; 3, *St. brevispinum*; 4, *Cosmarium abbreviatum* var. *planctonicum*; 5, *Pediastrum Boryanum*; 6, *Tabellaria fenestrata* var. *asterionelloides*; 7, *Asterionella formosa.*

V. 1, *Oocystis lacustris*; 2, *Pediastrum duplex*; 3, *Cosmarium abbreviatum* var. *planctonicum*; 4, *Tabellaria fenestrata* var. *asterionelloides.*

VI. 1, *Pediastrum Boryanum*; 2, *Staurastrum pelagicum*; 3, *Tabellaria fenestrata* var. *asterionelloides*; 4, *Campylodiscus Hibernicus*; 5, *Cymatopleura elliptica* var.; 6, *Surirella robusta* var. *splendida.*

PLATE VII.

Photomicrographs of plankton; I.–III. from Lough Leane, Kerry; IV., from Lough Guitane, Kerry; V. and VI., from Lough Mawmeen, Galway. All × 100.

I. 1, *Ceratium hirundinella*; 2, *Fragilaria capucina*; 3, *Peridinium alatum*; 4, *Oscillatoria Agardhii*; 5, *Melosira crenulata.*

II. 1, *Peridinium alatum*; 2, *Cœlosphærium Kützingianum*; 3, *Cymatopleura elliptica*; 4, *Synedra Ulna*; 5, *Asterionella formosa*; 6, *Tabellaria fenestrata* var. *asterionelloides*; 7, *Oscillatoria Agardhii*; 8, *Cyclotella compta.*

III. 1, *Anuræa cochlearis*; 2, *Notholca longispina*; 3, *Staurastrum Arctiscon*; 4, *Oscillatoria Agardhii*; 5, *Peridinium alatum*; 6, *Fragilaria capucina*; 7, *Melosira crenulata*; 8, *Asterionella formosa*; 9, *Tabellaria fenestrata* var. *asterionelloides.*

IV. 1, *Nauplius larva*; 2, *Anuræa cochlearis*; 3, *Staurastrum jaculiferum*; 4, *St. paradoxum* var. *longipes*; 5, *Anabæna flos-aquæ.*

V. 1 *and* 2, *Eudorina elegans*; 3, *Ceratium hirundinella.*

VI. 1, *Cœlosphærium Kützingianum*; 2, *Anabæna circinalis* var. *tenuis*; 3, *Ceratium hirundinella*; 4, *Peridinium alatum.*

PLATE VIII.

Photomicrographs of plankton; I.–IV. from Lough Conn, Mayo; V. and VI., Lough Cullin, Mayo. All × 100.

I. 1, *Ceratium hirundinella*; 2, *Sphærocystis Schræteri*; 3, *Cœlosphærium Kützingianum*; 4, *Melosira varians*; 5, *Surirella biseriata*; 6, *Tabellaria fenestrata*; 7, *Asterionella gracillima.*

II. 1, *Oscillatoria Agardhii*; 2, *Surirella biseriata*; 3, *S. robusta* var. *splendens*; 4, *Coscinodiscus lacustris*; 5, *Asterionella gracillima.*

III. 1, *Anuræa cochlearis*; 2, *Surirella biseriata*; 3, *S. robusta* var. *splendens*; 4, *Asterionella gracillima*; 5, *Anabæna flos-aquæ*; 6, *Ceratium hirundinella.*

IV. 1, *Sphærocystis Schröteri*; 2, *Cœlosphærium Kützingianum*; 3, *Cymatopleura elliptica* var.; 4, *Asterionella gracillima*; 5, *Ceratium hirundinella.*

V. 1, Spores of *Anabæna Lemmermanni*; 2, *Anabæna circinalis* (fragment); 3, *Cœlosphærium Kützingianum*; 4, *Asterionella formosa*; 5, *Bosmina longirostris.*

VI. 1, *Anabæna circinalis*; 2, Spores of *A. Lemmermanni*, in masses; 3, *Asterionella gracillima*; 4, *Fragilaria Crotonensis.*

PLATE IX.

Photomicrographs of plankton from Lough Corrib, Galway: I. and II. × 100; III.–VI. × 200.

I. 1, *Anuræa cochlearis*; 2, *Staurastrum paradoxum* var. *longipes*; 3, *Cymatopleura Solea*; 4, *Cym. elliptica* var.; 5, *Surirella biseriata*; 6, *Gomphosphæria lacustris*; 7, *Ceratium hirundinella*; 8, *Asterionella gracillima.*

II. 1, *Eudorina elegans*; 2, *Staurastrum paradoxum*; 3, *Chroococcus limneticus* var. *subsalsus*; 4, *Gomphosphæria lacustris*; 5, *Cyclotella Schræteri*; 6, *Asterionella gracillima*; 7, *Ceratium hirundinella.*

III. 1, *Asterionella formosa*; 2, *Cyclotella Schræteri*; 3, *Asterionella gracillima.*

IV. 1, *Cosmarium depressum*; 2, *Gomphosphæria lacustris*; 3, *Tabellaria fenestrata*; 4, *Ceratium hirundinella.*

V. 1, *Pediastrum duplex*; 2, *Staurastrum furcigerum* var. *reductum*; 3, *Gomphosphæria lacustris*; 4, *Asterionella formosa*; *Chroococcus limneticus* var. *subsalsus.*

VI. 1, *Staurastrum brevispinum*; 2 and 3, *Surirella biseriata*; 4, *Gomphosphæria lacustris*; 5, *G. aponina.*

PLATE X.

1–4. *Myxonema subsecundum* (Kütz.) Hazen. × 500. 4, filament from which zoogonidia have escaped.

5, 6. *Microspora amœna* (Kütz.) Rabenh. var. *irregularis* var. n. × 500.

7, 8. *Eudorina elegans* Ehrenb. Two curious forms. × 500.

9–11. *Aphanothece clathrata* sp. n. 9 and 10, outlines of colonies, × 200; 11, some of the cells, × 600.

12–14. *Scenedesmus bijugatus* (Turp.) Kütz. forma *arcuatus* (Lemm.) nob. × 500.

15, 16. *Glœocystis gigas* (Kütz.) Lagerh. var. *planctonicus* var. n. × 500.

17–19. *Closteriopsis longissima* Lemm.

PLATE XI.

1, 2. *Synedra Lemmermanni* sp. n. × 500. The markings are not indicated.

3, 4. ,, *Acus* (Kütz.) Grun. var. *angustissima* Grun. × 500. The markings are not depicted.

5–7. *Rhizosolenia morsa* sp. n. × 500. The setæ as reproduced are rather too stout.

8. ,, *longiseta* Zach. × 500.

9. *Pleurotænium Ehrenbergii* (Bréb.) De Bary. × 500. With parasitic fungus.

10. *Staurastrum dorsidentiferum* sp. n. × 520.

11. ,, *denticulatum* (Näg.) Arch. × 500.

12. ,, *furcigerum* Bréb. var. *reductum* var. n. × 500.

13–15. *Xanthidium subhastiferum* West. × 500. Three abnormal forms.

16. *Staurastrum dejectum* Bréb. forma. × 500.

17–19. *Staurastrum jaculiferum* West. × 500.

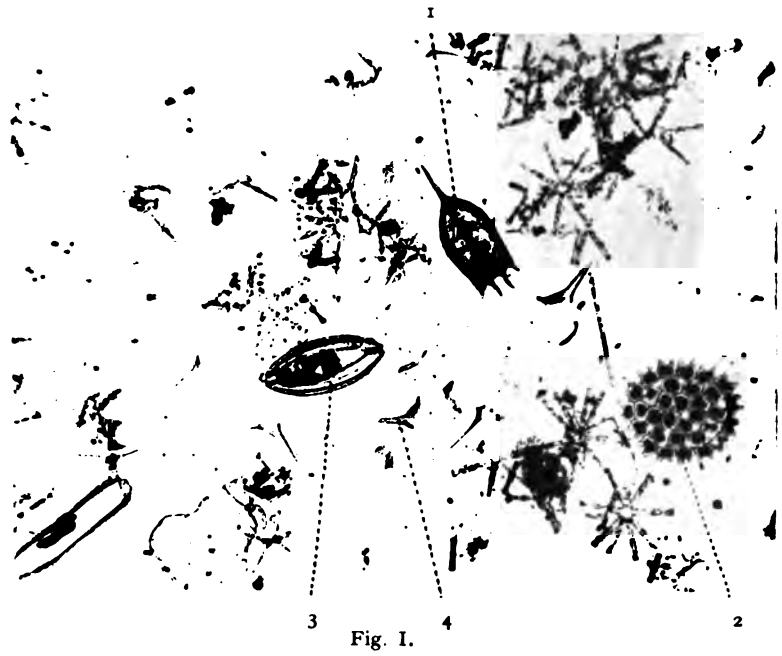
20, 21. *Cosmarium Corribense* sp. n. × 500.

22. ,, *subtumidum* Nordst. var. *Klebsii* (Gutw.) W. & G. S. West forma. × 500.

23. *Desmidium Pseudostreptonema* W. & G. S. West. × 500.

24–27. *Gomphosphæria lacustris* Chodat. × 500. 26, partially disorganized; 27, radiating mucus after the cells have been removed.

28–30. *Oscillatoria Agardhii* Gomont. × 600.



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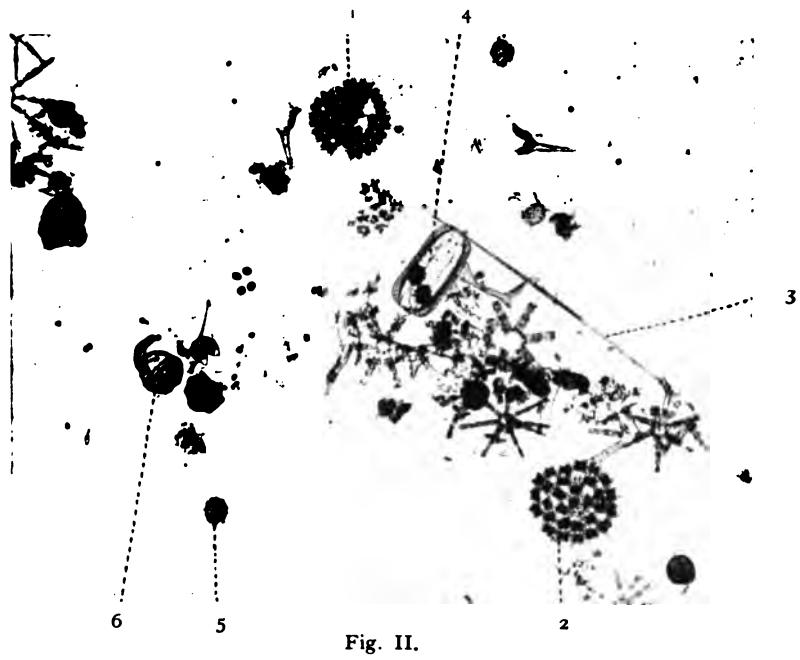

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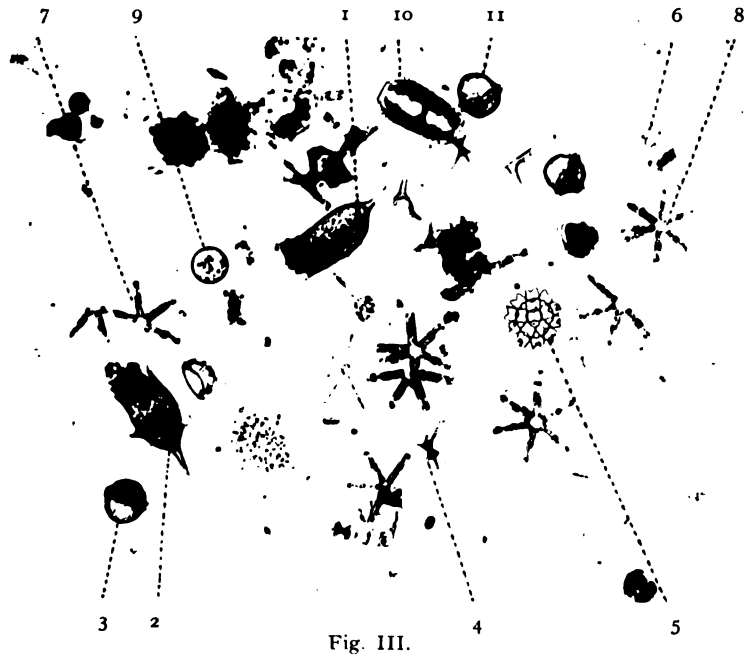

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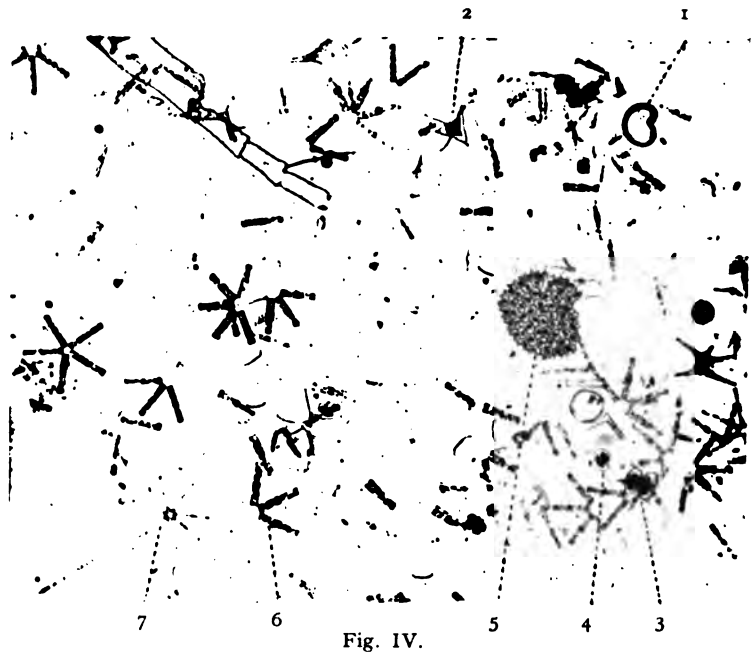

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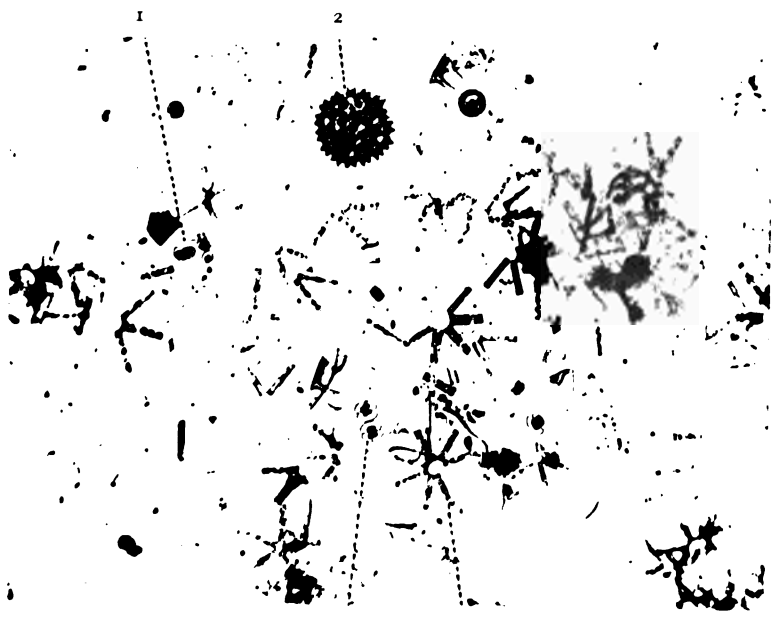

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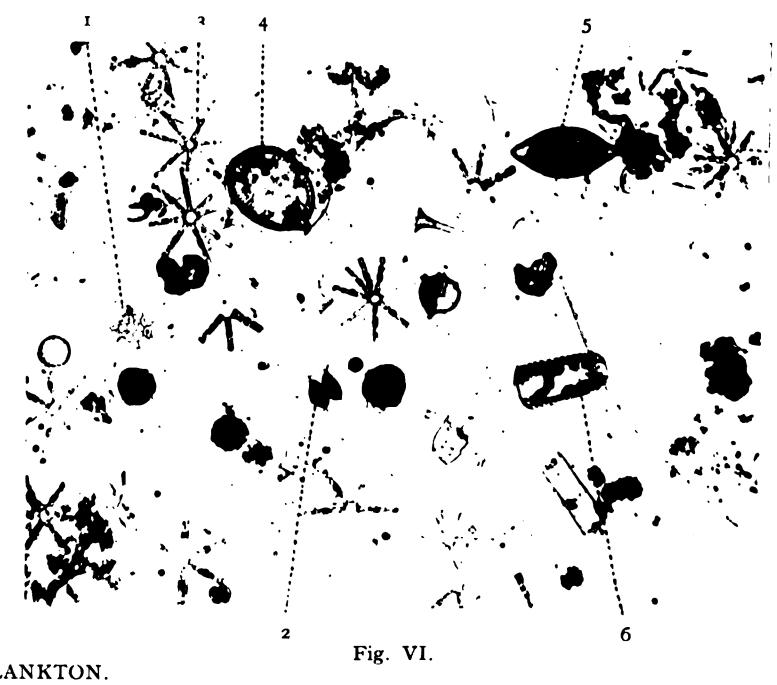
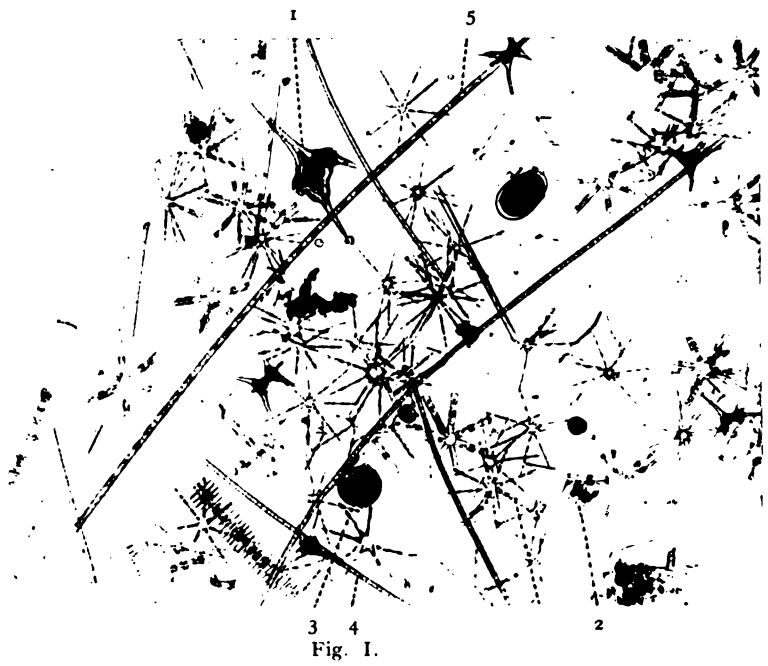


Fig. VI.

IRISH PLANKTON.

G. S. West, Photomicrogr.



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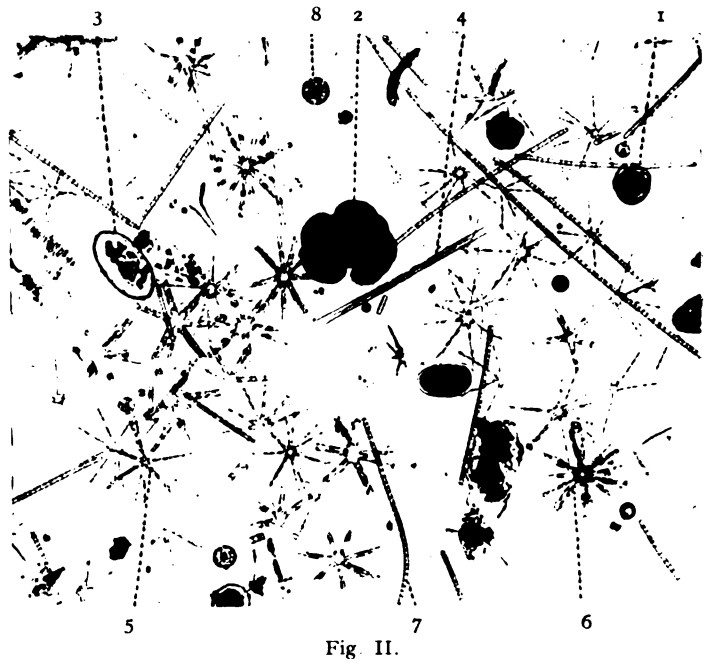

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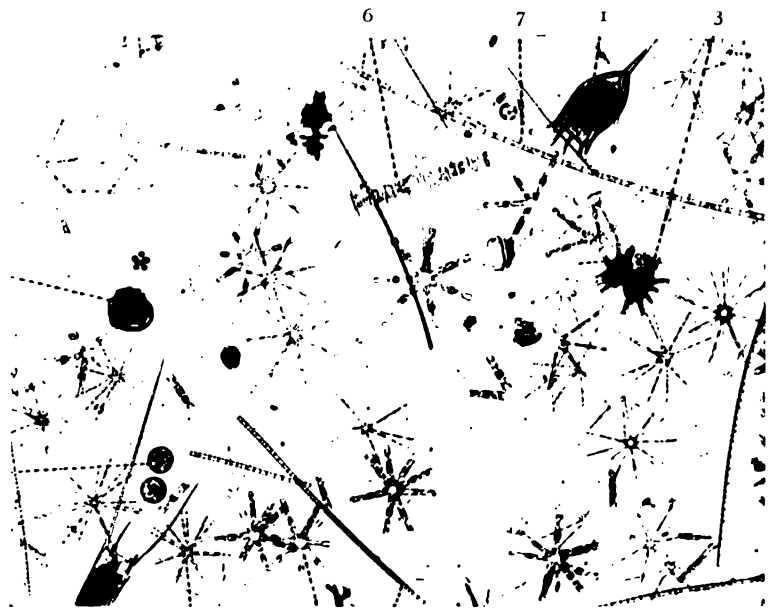

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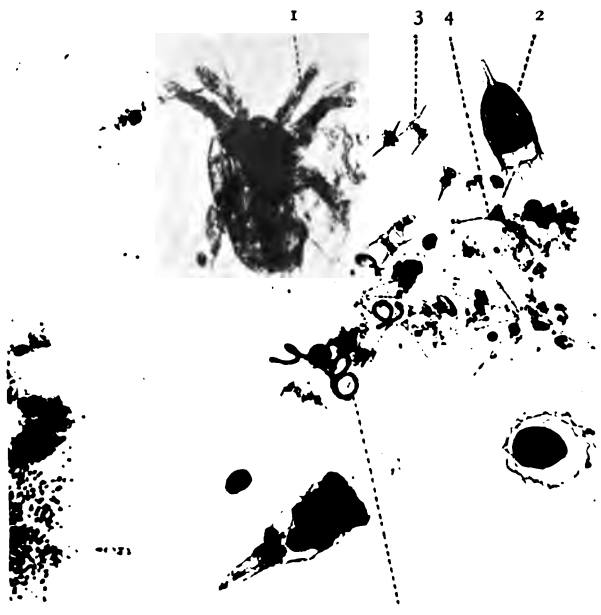


Fig. IV.

Fig. V.

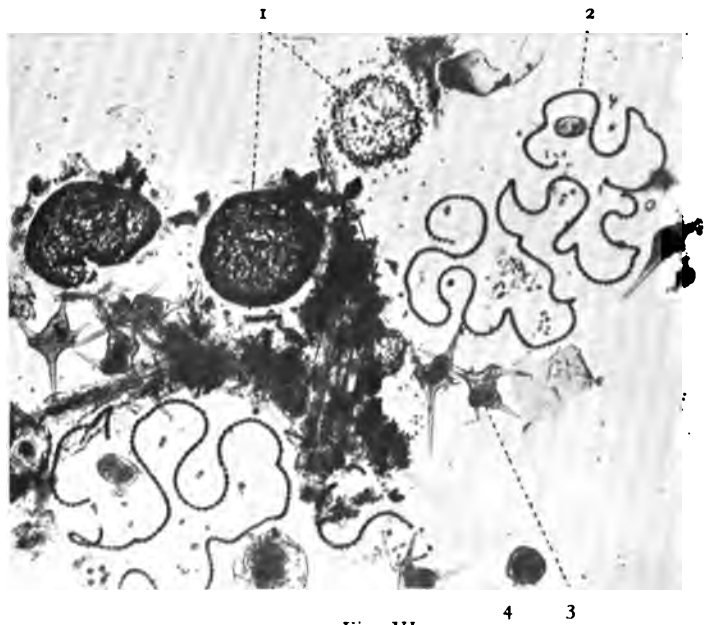
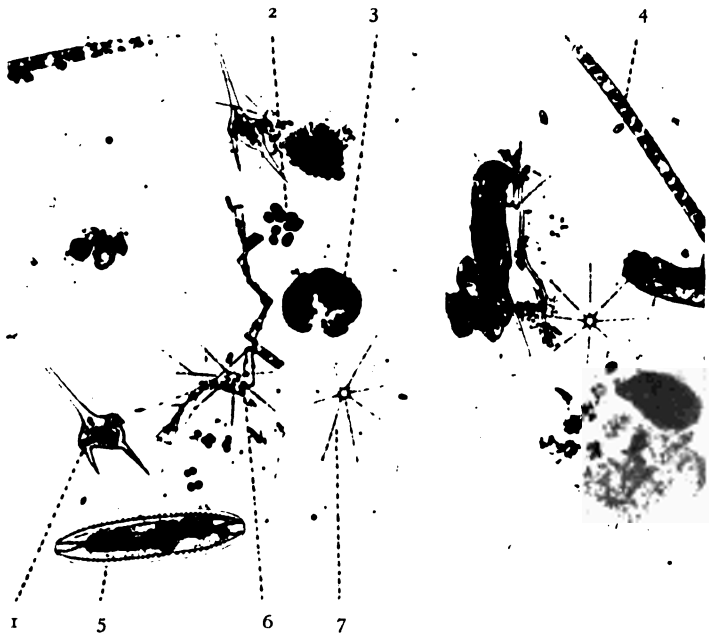


Fig. VI.

IRISH PLANKTON.

G. S. West, Photomicrogr.



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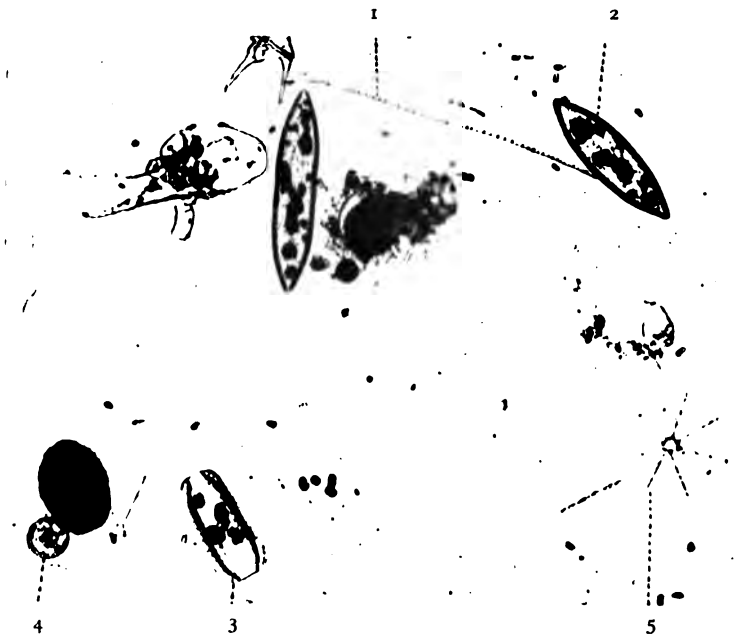

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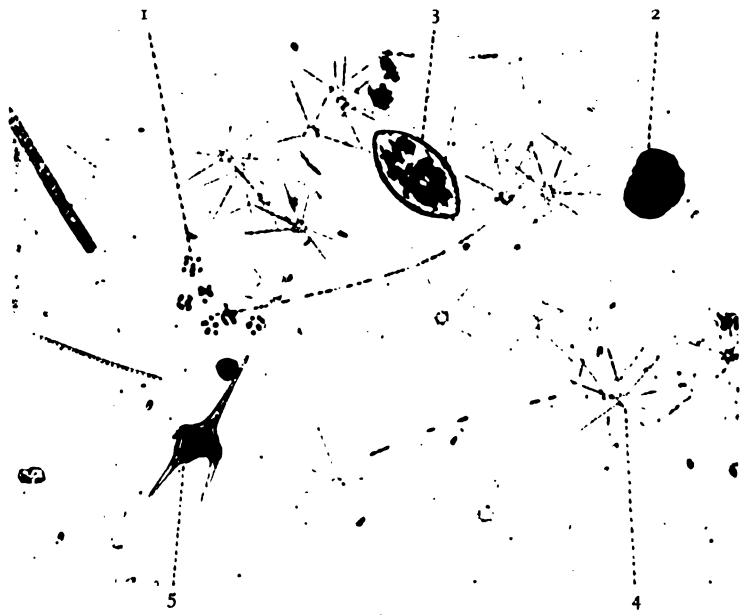
Fig. III.



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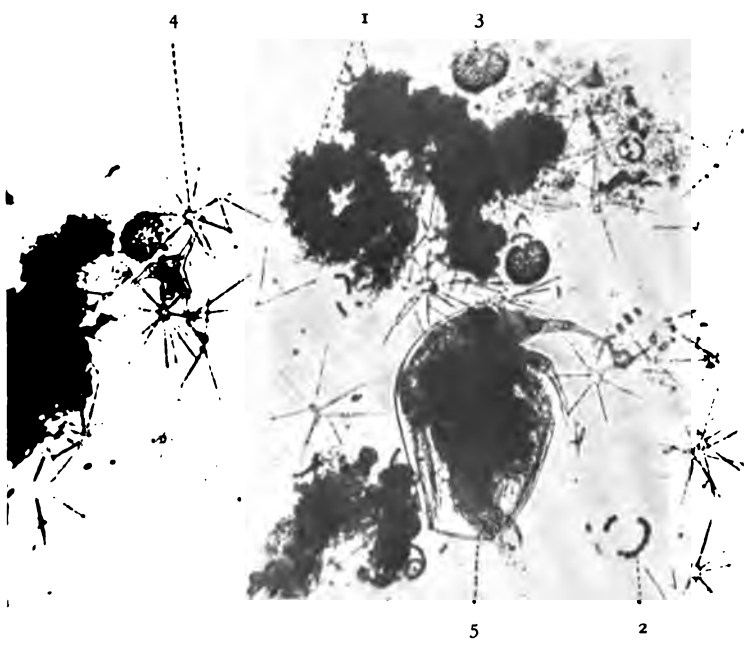

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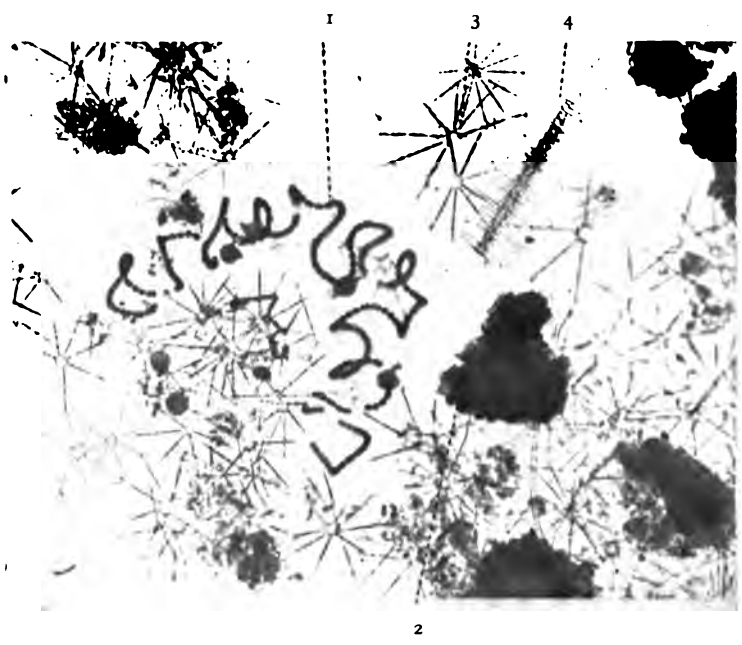
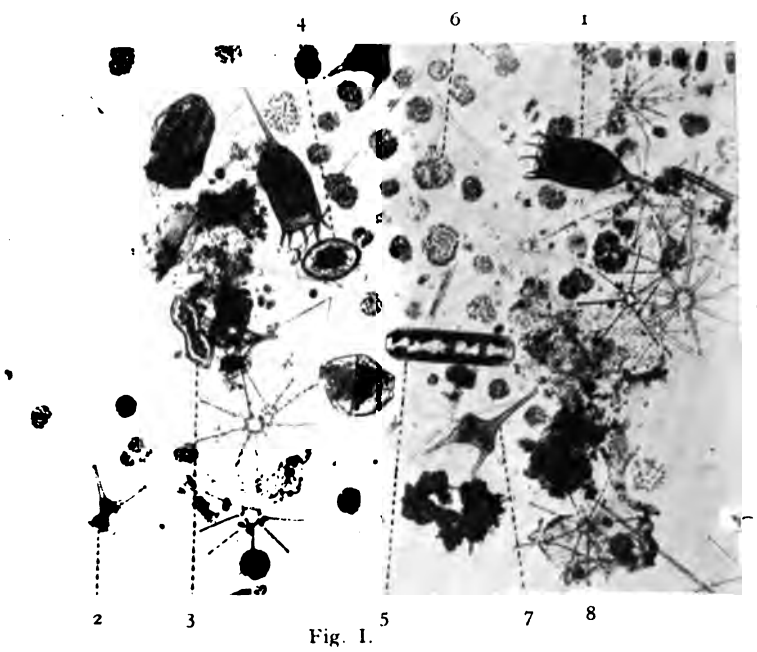


Fig. VI.

IRISH PLANKTON.

G. S. West, Photomicrogr.



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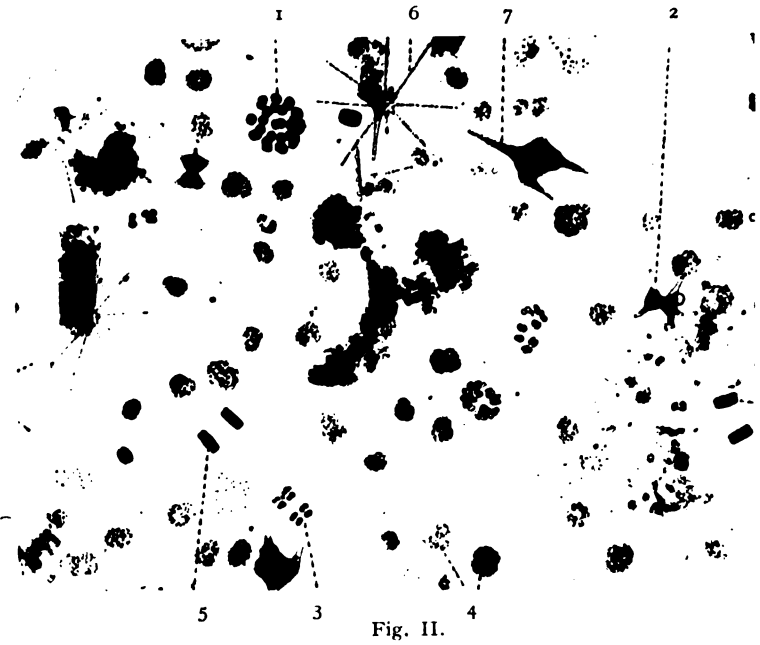

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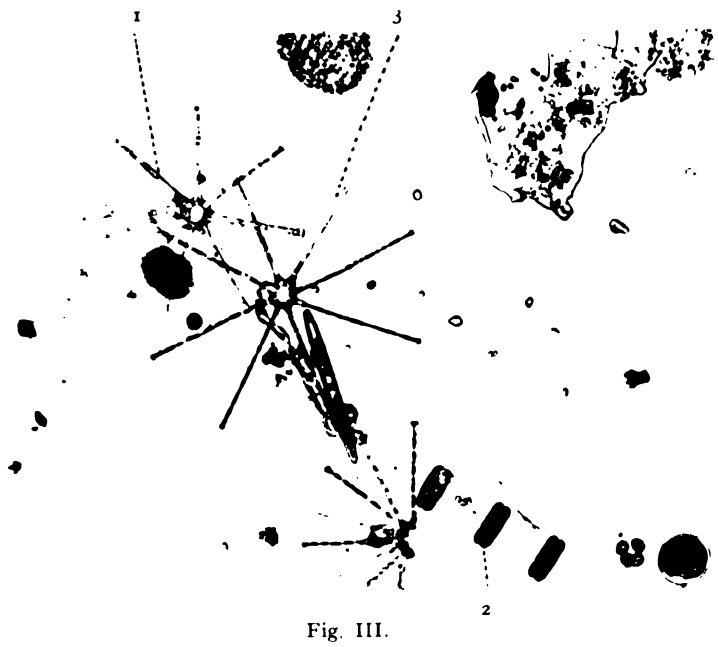

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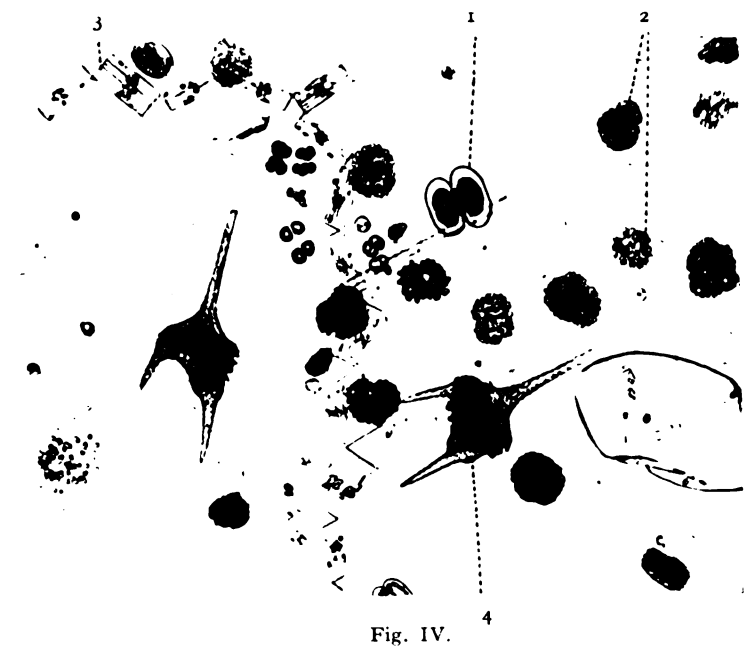

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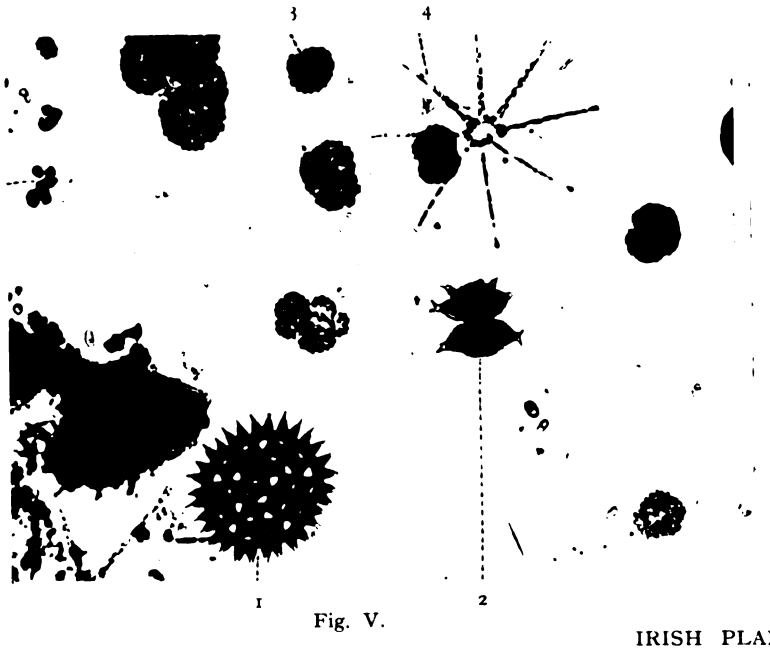


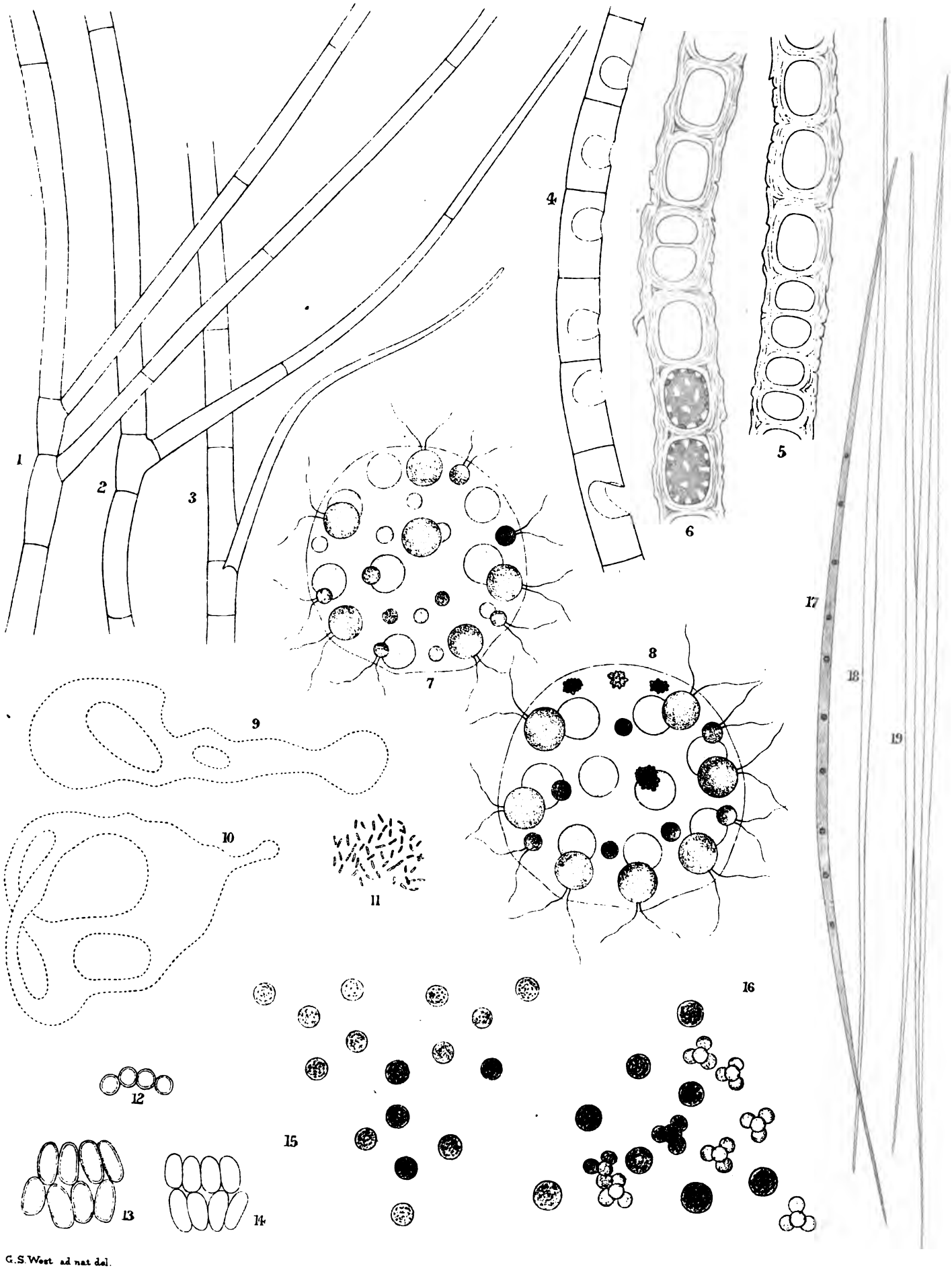
Fig. V.

Fig. VI.

IRISH PLANKTON.

G. S. West, Photomicrogr.

Plate X.



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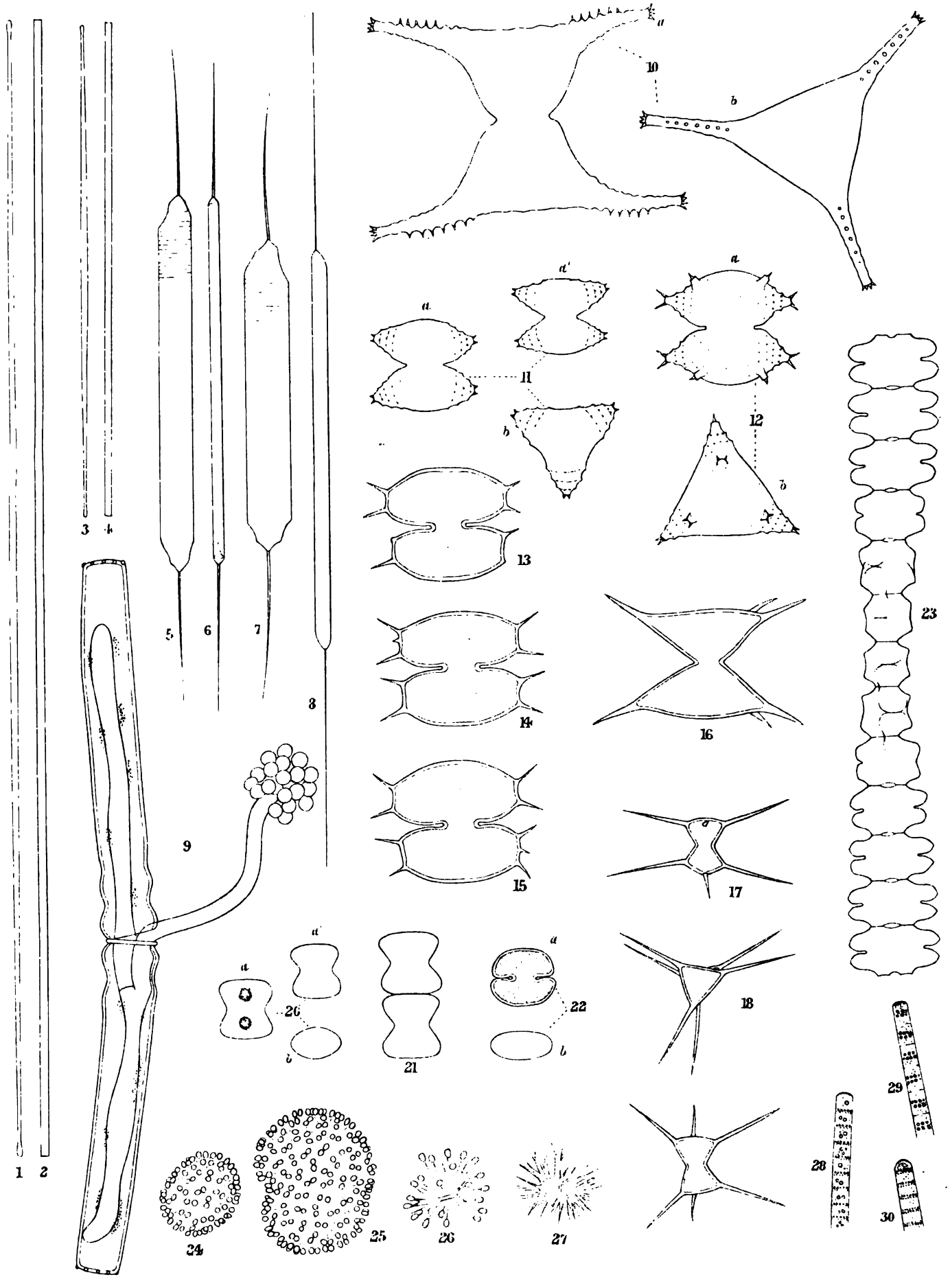

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