PROCEEDINGS AND REPORTS

of the

BELFAST NATURAL HISTORY AND PHILOSOPHICAL SOCIETY

For the

Session 1921-22.

Price - - - - Five Shillings.

BELFAST:
THE NORTHERN WHIG, LTD., COMMERCIAL BUILDINGS, BRIDGE ST

1923.

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The Council urgently request that any "find" of Archaeological interest in Ulster, should at once be reported to Mr. H. C. Lawlor, M.R.I.A., Hon. Secretary of the Archaeological Section, B.N.H.P.S., 8, Windsor Ave., Belfast.

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BELFAST NATURAL HISTORY AND PHILOSOPHICAL SOCIETY

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SESSION 1921-22.

Edited by
Arthur Deane, M.R.I.A
Hon. Secretary

BELFAST
THE NORTHERN WHIG, COMMERCIAL BUILDINGS, BRIDGE STREET,

1923.

BELFAST NATURAL HISTORY AND PHILOSOPHICAL SOCIETY.
[ESTABLISHED 1821.]

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The membership of the Society consists of Shareholders, Annual Subscribers, and Honorary Members.

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In 1914 a new class of membership was created including persons of either sex, to be elected under the bye-laws of the Society, and admitted by the Council on payment of ten shillings per annum. Such members have all the privileges of the Society, and take part in any business of the Society not affecting the ownership of the property of the Society. In 1917 an Archaeological Section was founded. Persons wishing to join the Section must be members of the Society and pay an additional minimum subscription of five shillings per annum. An Application Form for Membership to the Society and to the Section will be found on page vii.

A general meeting of Shareholders and Members is held annually in June, or as soon thereafter as convenient, to receive the Report of the Council and the Statement of Accounts for the preceding year, to elect members of Council, to replace those retiring by rotation or for other reasons, and to transact any other business incidental to an Annual Meeting.

The Council elect from among their own number a President and other officers of the Society.

Each member has the right of personal attendance at the Ordinary lectures of the Society, and has the privilege of introducing two friends for admission to such. The session for lectures extends from November to May.

Any further information required may be obtained from the Hon. Secretary at:—The Museum, College Square North, Belfast.

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Founded 5th June, 1821.

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To be filled up by the Candidate.

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........................., being desirous of becoming a Member of the Society, I, the undersigned member, recommend........ as a suitable candidate for election.

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Hon. Secretary,
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The Museum,
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5th October, 1921.

PROFESSOR GREGG WILSON, Ex-President, in the Chair.

"THE CONQUEST OF LAND AND AIR: A STUDY IN NATURAL HISTORY."

BY PROFESSOR J. ARTHUR THOMSON, M.A., LL.D., F.R.S.E.

(*Abstract*).

Over and over again in the history of life there have been attempts to get out of the water on to dry land. Plants prepared the way for animals. The first important invasion was on the part of worms, and from that there eventually resulted the making of good soil. The second great invasion was on the part of air-breathing jointed-footed animals, and this led eventually to the very important linkages between flowers and their insect visitors. The third great invasion was on the part of ancient amphibians, and this led on to the evolution of the higher land-animals, with great improvements in wits and in parental care. The conquest of the dry land implied new ways of breathing, new protections, new adjustments to the seasons, new ways of caring for its young. There are interesting betwixt-and-between animals, like land-crabs, shore-skippers, and mud-fish, which gives us hints as to the ways in which the transition from water to dry land may be effected. The surface of the earth has its peculiar difficulties and dangers as a home of life, and so we understand why many land animals became burrowers, and others climbers, and others cave-dwellers.

The last haunt to be conquered was the air, and although no animals are altogether aerial, the problem of true flight has been solved four times—by insects, by the extinct flying dragons or Pterodactyls, by birds, and by bats. It is interesting to contrast these four solutions, for they are all different.

The possession of the air meant greatly increased safety, greatly enhanced independence, improved locomotion and means of following food, and even that circumvention of winter which we see in migratory birds.

Of great interest are the half-way solutions of the flight problems, as in " flying " fishes, " flying " tree toad, " flying " lizard, and several " flying " mammals—none flying in the true sense, but many attaining to great excellence in parachuting. The familiar case of the aerial journeys of gossamer spiders shows how there may be a sort of flight without wings, and is a fine instance of life's insurgence.

The Chairman formally conveyed the thanks of the Society to Professor Thomson for his instructive lecture.

8th November, 1921.

PROFESSOR GREGG WILSON, Ex-President in the Chair.

"THE PUBLIC APPRECIATION OF ART."
By IVOR BEAUMONT, A.R.C.A. (Lond.), M.S.A., F.R.S.A., F.I.B.D., Head Master, School of Art, Municipal College of Technology.

[*No Abstract.*]

29th November, 1921.

PROFESSOR GREGG WILSON in the Chair.

"RECENT INVESTIGATIONS ON THE FUEL PROBLEM."
By PROFESSOR H. WREN, M.A., D.Sc., Ph.D., Professor of Chemistry, Municipal College of Technology.

[*No Abstract.*]

13th December, 1921.

PROFESSOR GREGG WILSON, ex-President of the Society, in the Chair.

ULSTER PHILOSOPHERS.

By PROFESSOR JOHN LAIRD, M.A., Professor of Logic and Metaphysics, Queen's University, Belfast.

ABSTRACT.

I have called this lecture "Ulster Philosophers," not "Ulster Philosophy," because there is no such thing as Ulster Philosophy. That is to say, the red-handed province has no continuing philosophical tradition in it of any kind—nothing either autochthonous or imported that was born, grew and died. On the other hand, quite a large number of philosophers of varying degrees of eminence have been connected with the province.

In certain ways, however, my subject offers difficulties concerning what should be included and what omitted. It is not very clear whom one ought to count a philosopher or how rigorous one should be in excluding all save genuine Ulstermen from consideration. In a word, on both of these points I must claim the lecturer's privilege of using his own judgment. I shall, in fact, be satisfied with any degree of affinity to Ulster which I deem sufficient, and as for the people I am to reckon philosophers I shall follow the somewhat shifting boundaries of the usual books. In truth, no one has yet succeeded in defining what is meant by a philosopher in such a way that all reasonable people (or even all who consider themselves philosophers) would admit the truth or the sufficiency of the description. To choose an example, everyone would admit, I suppose, that Herbert Spencer was a philosopher—that is to say, he would have to be included in all the books, whatever might be thought of the merits of his speculations; but it would be a much more delicate matter to decide whether or not Carlyle was to be accounted a philosopher. Anyone who wrote about his "philosophy" would have to suffer the distressing accusation of trying to be popular—presumably because a great many people were interested in Carlyle. Finally, if you said that Mr. Thomas Hardy was a philosopher you would be taking even greater risks. Incredible as it may seem, you might have ceased to be respectably academic.

Consequently, as I say, I am going to use my own judgment in these confusing matters, and as I have to speak only of individual men and not of "movements" or "currents of thought" I am naturally bound to choose a merely chronological order of arrangement.

I shall pass over the Middle Ages very rapidly, partly because Ulster had not then attained the fame in the world with which we are now acquainted, partly because time has effaced the recorded thoughts of her philosophers (if any such were recorded), and principally because I know very little about the matter. Still I have a little—a very little—to say even here.

The name of Duns Scotus (whose dates are approximately 1265 to 1308) has a very distinguished place in the roll of the great schoolmen, and the name of Johannes Scotus Erigena (who flourished in the ninth century) recalls us to one of the very few among the forerunners of the scholastics who are worth considering.

Now the second of these—Johannes Scotus Erigena—was quite certainly an Irishman. The word Erigena plainly means "hailing from Erinn," and to make assurance doubly sure, "Scotus" then meant "Irishman" too. Therefore Scotus Erigena was certainly born in Ireland, and so, of course, he *may* have been born in Ulster. On the other hand, no one knows where he was born, so it would be rash to pursue the point, and it must be admitted that the literary activities of Scotus Erigena had no connection with

Ireland at all. The best part of his life was spent in France at or near the court of Charles the Bold, and although according to the legend he was one of the "merchants of wisdom" who crossed in a stream from Ireland to Paris (one hopes their trade was good): he does not seem to have been inordinately proud of his native land. At any rate, one of the few witticisms which have survived from this rude period is a reply he made to Charles the Bold. Charles asked "Quid distat inter sottum et Scottum?" (What is there between a sot and a Scot or Irishman) and Erigena replied "Mensa tantum" (which is, being interpreted, "Just a table").

To cut a long story short, I have not the face to say anything more about Scotus Erigena. I admit, of course, that he was a very great man. despite the pun which the historians bring up against him.

The case of Duns Scotus is distinctly different. By the thirteenth or fourteenth centuries, it appears, Scotus had come to mean "North Briton," at any rate in Franciscan literature. And Duns Scotus was a Franciscan. The probabilities, therefore, appear to be that Duns Scotus was not an Irishman at all, and it may even be the case that he was called Duns because his birthplace was Dunse in Berwickshire, or because it was Dunstane in Northumberland (as a manuscript in Merton Library asserts). On the other hand, it was claimed by Hugh MacCaghwell, who was Archbishop of Armagh early in the 17th century, that Duns was an Irishman after all, and that Duns is just Down; and several writers, not all Irish, have followed the archbishop in this.

Consequently, if Duns Scotus really was an Irishman (which is unlikely) then it is highly probable that he came from Down, and with this crumb of comfort I must leave him. He also was a very great man—not a mystic like Scotus Erigena, but none the less a very great man. Indeed, it may fairly be claimed, I think, that no one has come so near as he and his pupil Ockham to what is called nowadays "scientific method in philosophy," and any competent person will admit, I think, that this means that the Subtle Doctor (as Duns was called) was a very acute person indeed. However, he also was a cosmopolitan, as a tombstone erected to his memory at Cologne asserts. "Scotia me genuit" (whether Ireland or Scotland does not matter), it declares, "Anglia me suscepit (that was Oxford), Gallia me docuit (an untrustworthy legend makes him out to have been a regent of the University of Paris), Colonia me tenet." I do not think, therefore, that we have any right to dwell upon him longer now.

Passing to the seventeenth century we come first to Bishop Jeremy Taylor. Jeremy Taylor's claims to be counted among the philosophers are, as I think, incontestable. Primarily, of course, he was a notable divine, one of the very greatest in the greatest age of English divinity, and his *Liberty of Prophesying*, his *Holy Living*, and his *Holy Dying* are his most enduring monuments—more enduring even than the one which stands to-day in the cathedral at Dromore. On the other hand, every treatise on British ethics gives some account of his *Ductor Dubitantium*, which he completed in his study at Portmore in the parish of Ballinderry, some eight miles from Lisburn, in the year 1659, at the very moment when Cromwell's Anabaptist commissioners were knocking at his gates and summoning him to explain himself to them in Dublin. A recent historian of English philosophy states, indeed, that the *Ductor Dubitantium* in "perhaps the greatest treatise on casuistry ever written by a Protestant theologian." "He will not collect individual cases of conscience," this historian goes on, "for they are infinite; but he seeks to provide 'a general instrument of moral theology, by the rules and measures of which the guides of souls may determine the particulars that shall be brought before them'." And our commentator concludes thus—"The whole forms a comprehensive treatise on

Christian ethics, based undoubtedly upon traditional scholastic doctrines, but holding firmly to the inwardness of morality, and illustrated by an extraordinary wealth of concrete examples."

There is no doubt, then, that Jeremy Taylor was an eminent philosopher, but, of course, he was not an Ulsterman. He was born at Cambridge in 1613, and he spent the greater part of his life in England, feeling to the full the stress of the times, for he was chaplain to Laud, then chaplain in ordinary to Charles I., and he was taken prisoner in the royalist defeat before Cardigan Castle on February 4, 1644-5. On the other hand he spent the last ten years of his life in Ulster; Down and Connor was the only bishopric he ever held; and he died in Lisburn in 1667 of a fever he had caught when visiting a sick parishioner there. These facts, I think, justify me very fully in considering him here, but even if they did not I could still defend myself by pointing out that he had, to this day, an enduring influence upon Ulster life. Jeremy Dunensis stirred up the Presbyterian clergy so thoroughly that he consolidated the ranks of these "Scotch spiders" (as he called him) in such a way that the solidity of Presbyterianism in Ulster is due as much to this cause as to any other single episode.

In truth Jeremy Dunensis had a bad time with these Presbyterian ministers, although he appears to have behaved with dignity and tact towards the Presbyterian gentry. Things were not so bad at first. After much persuasion from Conway of Ballinderry he came over to Ireland in 1659 with a pass under Cromwell's sign-manual giving protection to himself and to his family in order to undertake the work of what was called a "weekly stipendiary lectureship" at Lisburn. Now in these days the Ulster Presbyterians did not like Cromwell. They had protested against the execution of Charles I., and Milton had called them the "blockish presbyters of Claneboye." Taylor did not quarrel with them *then*, therefore—indeed, as we have seen, he was subject to the same sort of persecution as they were from these Anabaptist commissioners in Dublin. But with the Restoration all was changed. Taylor, it is true, came into his own, and after a delay, which can scarcely be accounted for by the absence of the appropriate seal (which was the excuse given), he was duly installed Bishop of Down and Connor. But the Presbyterians came into their own, too. It was held that their loyal sentiments during the Protectorate gave them a legal right to the tithes and the twentieth parts, and therefore, with some reason, they refused to submit to an Episcopalian bishop.

So there was strife. Jeremy Dunensis refused to recognise them "as a body." They refused to recognise Jeremy Dunensis. Jeremy explained to Ormonde that he "would rather be a poor curate in a village church than a bishop over such intolerable persons," and he explained also that he was "perpetually contending with the worst of the Scotch ministers." The Scotch ministers retaliated by nosing out traces of what they considered Arminianism in the Bishop's writings, and they made representations to Dublin accordingly.

Taking it all in all, Jeremy Taylor did not like Ulster. "I will petition your Excellency," he says, writing to Ormonde again, "to give me some parsonage in Munster that I may end my days in peace." *Per contra* (perhaps) his last words as he lay dying in his house at Lisburn were, "Bury me in Dromore."

There is one other episode in his life in Ulster, however, which I must mention before I pass on. It has to do with psychical research. According to the "relation" given by one Thomas Alcock, secretary to Bishop Jeremy Taylor, and published in the contemporary *Sadducismus Triumphatus* of Joseph Glanvil, the Bishop of Down investigated the case of an apparition which had appeared to a certain James Taverner. The examination took place in the first instance at Dromore. but the bishop afterwards took Taverner with him to Hillsborough (Hilbrough) because he was informed that " my lady Conway and other persons of quality were come purposely to hear his Lordship examine the matter."

The tale is a long one, and I have time to give the gist of it only. In Michaelmas, 1662, James Taverner, described as a " lusty proper stout fellow then servant at large to the Earl of Chichester," was riding home from Hillsborough to the Earl's house in Belfast when his horse shied at Drumbridge. The cause of the animals's fright was an apparition who described himself to Taverner as James Haddock, formerly of Malone This apparition claimed acquaintance on the ground that Taverner had brought the Haddock family some nuts five years before.

The former wife of the apparition (maiden name Eleanor Welsh) had now married a man called Davis, who held the lease of Malone, and the apparition contended that the lease belonged legally to John Haddock, his son by this lady. Mrs. Davis, however, was unwilling to act in the matter. When Taverner, instructed by the apparition, called on her first she put him off by saying that there was another Eleanor Welsh. The apparition, however, was exceedingly persistent. It appeared every night for more than a month, generally wearing a white coat, but sometimes assuming " many formidable shapes," and vanishing either with " hideous screeches and noises " or else " in a flash of brightness ": and once it apeared to Taverner when he was sitting with friends in the house of one Pierce, a shoemaker in Belfast. On this occasion, however, no one saw the ghost except Taverner, though all heard him addressing it and for this reason perhaps Dr. Lewis Downs, then minister of Belfast, attributed the ghost, in the phrase of the times, " rather to melancholy than to anything of reality."

The Bishop, however, took Taverner seriously, and advised him the next time he saw the spirit to ask him certain questions, such as, " Are you a good or a bad spirit? How are you regimented in the other world? Why do you appear for the relief of your son in so small a matter when other spirits do not for greater cause?" This advice was very wise. The spirit appeared again to Taverner, it is true, this time at Lord Conway's house at Hillsborough; and Lady Conway and the other persons of quality saw Taverner trembling before it; but when Taverner asked his questions "It gave him no answer, but crawled on its hands and feet over the wall again, and so vanished in white with a most melodious harmony."

The boy, one gathers, was righted. According to the "relation" it was common report that he had been wronged.

I pass next to a genuine son of Ulster, William King, Archbishop of Dublin, who was born in the town of Antrim in 1650, his father having fled thither from Aberdeenshire to avoid the Solemn League and Covenant.

King's title to eminence in philosophy (and it is a very sound one) is derived principally from his book *De Origine Mali*, an attempt (on a philosophical basis similar to Locke's) to reconcile the conflict between the existence of evil and the omnipotence of a benevolent deity. This work had European influence. Bayle, the sceptical author of the celebrated *Dictionary*, replied to it; so did the great philosopher Leibniz; so did Wolff: and to this day the ordinary student of philosophy hears of it, although in a rather curious way. The book was translated by Law and in an edition of 1731 John Gay prefixed a dissertation to this translation. This dissertation gives in simple outline the theory which Paley later made fashionable, and thus it comes about that King's Latin work, so renowned in its day, is now remembered principally because a preface to a translation of it is one of the chief landmarks in the history of the celebrated utilitarian theory.

A short account of King's life, however, may prove of greater general interest. After receiving his early education at a Latin school in Dungannon, King went to Dublin, and had a stormy and a busy career. He was a warm supporter of the Prince of Orange, and on this account was imprisoned by the Tyrconnel Government in 1689. The Battle of the Boyne, however, brought him release, and he preached the thanksgiving service in St. Patrick's Cathedral, which commemorated "the preservation of his Majesty's person, his good success in our deliverance, and his safe and happy return into England."

He became Bishop of Derry in 1690-91; and there he also had trouble with the Presbyterians, whom he found "mighty insolent." On the other hand, unlike Jeremy Taylor, he was a stalwart Irishman, and whereas Jeremy Taylor had deprecated the Irish tongue (that is putting it mildly) and had entreated that all should be taught English "that they may understand and live," King made arrangements that a Gaelic colony in the Inishowen Peninsula should have a clergyman sent them who could speak their own language. In a word, Orangeman as he was, he was also the leader of the party opposed to the English interest in Ireland, and after he was appointed Archbishop of Dublin he wrought mightily (for many years with the aid of Swift) to this end.

The next philosopher with whom we have to deal is the celebrated Toland the Deist. Janus Julius Toland changed his name to John very early in life in order to avoid the ridicule of his schoolfellows, but he had to face ridicule (and worse) during the whole of his extraordinary career. On the other hand, adventurer, starveling, spy and Grub Street hack, as he was by turn, he was certainly a pioneer in the history of free thought in England, and he deserved praise and fame as well as the somewhat dubious notoriety which was all he achieved in his lifetime.

Toland was born on the Inishowen Pensula in 1670. He was illegitimate, and his enemies declared (maliciously, no doubt, but perhaps truly) that his father was a priest. Be that as it may, Toland had the best possible education for a freethinker, since warring sects strove for the possession of him. Bred a Catholic up to the age of 16, he was then captured by "some eminent dissenters" (Presbyterians again, I suppose) who made a Protestant of him, and after some schooling at Redcastle, near Londonderry, he went to Glasgow University. Edinburgh gave him an M.B., and he then proceeded to Leyden where the echoes of Spinoza's *Tractatus Theologico—Politicus* could still be plainly heard. He returned to Britain in 1694, and stayed at Oxford, where his orthodoxy seems to have been suspect from the hour of his arrival. The proof appeared in 1696, when Toland published his *Christianity not mysterious.*

The work is undoubtedly rationalistic, but it is very far from being simply the cheap profligacy of a seeker for notoriety (as its many enemies alleged). On the contrary, it is seriously argued, and even moderate in its tone. Still the bishops and the clergy did not like it, and that is scarcely surprising. Locke's *Reasonableness of Christianity* was not to their liking either, and it had appeared shortly before; but whereas Locke had not openly flouted the mysteries of Christianity—his sole aim, professedly at least, was to show that Christianity was a reasonable religion—Toland went further, and argued that *because* Christianity was reasonable it could contain neither mystery nor miracle nor aught of the kind. The irony of this argument (which was quite in the style of the day) could not hoodwink a Churchman. And it did not.

The book raised a storm. It was burnt by the Grand Jury of Middlesex (who did not consider this action a compliment), and it drew the fire of the heavy artillery of the Church with more than military promptitude. The author had to leave Oxford and retire to Dublin. There he received, at first, something like a welcome. William Molyneux, for example, the student of optics who wrote the *Dioptrica Nova* with Flamsteed's help, the architect of that portion of Dublin Castle which stands on the Piazza, and the friend and correspondent of Locke, received Toland gladly, and did his best for him.* After a very short time, however, even Molyneux did not dare to countenance Toland openly. The deist had a way of feasting indiscreetly in coffee-houses (I do not suppose he was more sober than other honest Irish gentlemen), and the bailiffs dunned him for his wigs and his lodgings. Finally the Irish Parliament intervened. As South, the ecclesiastic says, "The Parliament to their immortal honour sent him packing, and without the help of a faggot soon made the kingdom too hot to hold him." South's one regret was that the rest of the kingdom was less torrid.

Toland in fact had offended the institutions of his country and he had a very lean purse. Therefore he suffered, like the most of the deists that succeeded him, for the double crime of poverty and *lèse majesté*. The deists did not fare well. They had to fight privilege, and they had also to fight an array of scholarship and ability far greater than their own. They were crushed, therefore, as thoroughly as Grub Street hacks and such-like *canaille* could be crushed; and yet, in the usual way of such affairs, their doctrine has lived. The eighteenth century was the flowering time of rationalism, deism, and their step-child scepticism. Shaftesbury, Bayle, Bolingbroke, Voltaire, Hume and the French encylopædists were far too important to be crushed: and they were not.

Returning to Toland, however, we must admit that his fate was as good as he deserved. He was born to live from hand to mouth and to get his ideas printed. And this, in a word, was the story of his career. He had his bad times, no doubt. As Sir Leslie Stephen says, "The poor man did not know how to starve," but generally he was able to stave

* So far as I know, Molyneux had no connexion with Ulster, but his son Samuel—who was a friend of Berkeley's—owned an estate in Armagh.

starvation off, and he had an interesting, if unconventional, career. Most of the remainder of his life after he left Ireland (he died in 1722) was spent on the Continent, where he was a political informer (a spy in plain language), a court sycophant and a hack writer by turns or all together. He was not troubled with too nice a conscience (for example, he printed Shaftesbury's *Inquiry* without permission when Shaftesbury was making the grand tour), and he did not object to his espionage, although, as he said (with an attempt at dignity), he would rather be a " private monitor and purveyor of education " than a spy.

We need not weep for him, therefore; and he was known to the most interesting people of his day. Leibniz, for example, respected his ability; a Turkish effendi inquired of Mr. Toland from Lady Mary Wortley Montagu; Prince Eugene of Holland befriended him, and Queen Sophia Charlotte of Prussia, sister of George I. and mother of Frederick the Great, received him at court, where she set the literary fashion which her belleslettristic warrior-son continued in the way that every schoolboy knows of. And Toland had help from England, too. He expected a good deal from Harley, and he got something. Shaftesbury, too, overlooking the incident of the pirated manuscript, paid him a pension for some years, although he withdrew it later in one of his fits of economy.

And Toland went on writing. He had learned more at Leyden from the rationalists than the simple tactics of frontal assault. He had also learned the other rationalistic method; the method of sapping and mining by research into the authenticity of the Sacred Texts and by attacking the character of the early Christian bishops. I have time only for two examples of this. To his *Mangoneutes being a defence of Nazarenus* he appends certain " queries to be sent to Christians residing in Mahomedan countries." One of them runs as follows: " Since we find that they charge our Gospel with corruption and alteration in many things, and particularly that Mahomet's name was raz'd out of 'em, as likewise out of the Pentateuch and the Psalms; you are to enquire of the most learned, judicious and candid among 'em, how they can prove such expunctions or interpolations, if they have no authentic copies to confront with ours?" (And so on. Toland's excursions into the higher criticism have not stood the test of time. He was not even a pioneer, except perhaps in England, but he was keen). The other quotation I shall give is the title page to his *Hypatia*. It runs, "Hypatia, or the history of a most beautiful, most virtuous, most learned and every way accomplished lady; who was torn to pieces by the clergy of Alexandria, to gratify the pride, emulation, and cruelty of their Archbishop Cyril, commonly but undeservedly stil'd Saint Cyril." Cyril's iniquity, in fact, is Toland's subject quite as much as Hypatia's virtue, but it is only fair to add that Toland's pamphlet does not assign too much space (for the times) in discussing the important question whether or not Hypatia *was* virtuous.

Writings such as these, as well as his *Letters to Serena* in which he makes suggestions towards a rationalistic philosophy to the Queen of Prussia, sum up his literary excursions. His last work, however, should receive some mention. It is not in good taste. He got it up like a prayer book, with red rubrics, and it contains the ritual of a pantheistic religion. But the most interesting point in it for us is that the writer returns in spirit to the name and place of his birth. The preface is signed Janus Julius Eoganesius. Now Inis Eoghain is Inishowen: and we have already seen the history of Janus Julius.

It is unfortunate for my purposes that Bishop Berkeley—the greatest of Irish philisophers—never resided in Ulster. He was a Kilkenny man, and Dublin was his spiritual home, as far as that was in Ireland at all. What is more, the slight connection he had with Ulster does not show that he had any love for the province. The matter befel in this wise. In the year 1721 Berkeley returned to Ireland after some eight years spent partly in London and principally on the Continent. "I had no sooner set foot on shore," he wrote to Sir John Percival in October of that year, "but I heard that the Deanery of Dromore was become vacant, which is worth about £500 a year and a sinecure; which circumstance recommends it to me beyond any preferment in the kingdom." Percival did his best for him, but without much success. On February 10 of the next year, it is true, Berkeley wrote that "his patent was now passing the seals," but he added that the Bishop "pretending a title hath put in a presentee of his own, which unavoidably engages me in a lawsuit."

Thereafter Berkeley experienced the law's delays. "God preserve your Lordship from law and lawyers," he wrote piously in April, 1722; and, indeed, he had little hope of success. "The suit," he wrote, "upon enquiry I find will be more tedious, and the event much more doubtful than I was at first aware of, but with a sure expense on my side, if I am informed right, of several hundred pounds besides what I am likely to get from the Government,* which will go but a little way to pay eight lawyers (for so many I have engaged) and to pay all other expenses of a suit against a man who is worth £1,200 p.ann., besides the Deanery which he is in actual possession of, and who hath been practised in lawsuits five and twenty years together."

The Bishop's motives, doubtless, were principally private and personal, but he may have known that Berkeley wanted a sinecure, and it is probable that he objected to Berkeley for precisely the reason that Percival thought in Berkeley's favour, viz.: that Berkeley had been as much in England as in Ireland for a great many years. (There is a hint, too, that B.'s politics were those of a mugwump.) However that may be, by the year 1723, while this lawsuit was still pending, Berkeley had made up his mind to go to Bermuda to found an Arcadian university in these summer

***Note—£50 concordation money had been voted him.**

islands both for white and coloured. He wished, indeed, not only to go there, but to maintain ten savages and ten whites at his own expense. This new purpose, he wrote, "sets me above soliciting anything with earnestness in this part of the world, which can now be of no use to me, but as it may enable me the better to prosecute that design; and it must be owned that the present possession of something in the Church would make my application for an establishment in these islands more considered. I mean a charter for a college there."

He wanted money, however, as well as the charter, although he had, quite unexpectedly, inherited half the estate (one Robert Marshal inherited the other half) of Hester Vanhomrigh, Swift's Vanessa, who had revoked her legacy to Swift in view of the Dean's conduct when he heard that she had questioned Stella concerning her relations with him. And an appointment came, too. "I can now tell your Lordship," he wrote to Percival in 1724, "that yesterday I received my patent for the best deanery in the kingdom, that of Derry. This deanery is said to be worth £1,500 p.ann., but then there are four curates to be paid and great changes upon entering, for a large house and offices, first fruits, patent, etc., which will consume the first year's profit and part of the second." However, Providence tempered the wind for him. "I am now on my return from Derry," he wrote a month later (May, 1724), "where I have taken possession of my deanery and farmed out my tithe lands, etc., for £1,250 a year. I am assured they are worth two hundred pounds per ann. more, but thought it better to have men of substantial futures engaged for the punctual payment of the foregoing sum than by keeping them in my hands to subject myself to all that trouble, and all those cheats which Dissenters (whereof we have many about Derry) are inclined to practice towards the clergy of our Church."

However, he was enthusiastic about the place. "The Cathedral," he went on to say in the same letter, " is the prettiest in Ireland. My house is a fashionable thing not five years old, and cost eleven hundred pounds. The Corporation are all good Churchmen, a civil people, and throughout English, being a colony from London. I have hardly seen a more agreeable situation, the town standing on a peninsula in the midst of a fine spreading lake, environed with green hills, and at a distance the noble ridge of Ennishowen mountains and the mighty rocks of Maghilligan form a most august scene. There is, indeed, much of the *gusto grande* in the laying out of this whole country, which recalls to my mind many prospects of Naples and Sicily."

Nevertheless he never went there again. Law-suits concerning the Vanhomrigh will and an attempt to obtain from the British House of Commons for the Bermuda scheme—a grant of £60,000 was voted, but never paid—kept him in Dublin or in London till 1728. Then he sailed for America. When he returned in 1731 it was to London that he came, and he did not take up residence in Ireland till 1733, when he was appointed Bishop of Cloyne.

On the whole then (save for this one week of his visit to Londonderry) his connection with Ulster is simply that he got something out of her.

Francis Hutcheson (1694-1746) is commonly regarded as *the* Ulster philosopher, and certainly he was both an Ulsterman and a philosopher. The facts of his life are briefly as follows. He was the second son of John Hutcheson, Presbyterian minister of Ballyrea, near Armagh, but he seems to have been born at his grandfather's house at Drumalig in County Down. This grandfather, Alexander Hutcheson was a Plantation Scot who was minister of Saintfield in Co. Down for the greater part of his life, and had wealth enough to purchase the estate of Drumalig. Francis Hutcheson's mother was a Longford lady.

Francis was educated at a Dissenting school near Saintfield, and thereafter at the Academy (as it was called) of Killyleagh. Thence, like the other local Dissenters in Ulster, he proceeded to the University of Glasgow, sitting under Gershom Carmichael and others. At Glasgow he seems to have studied diligently, and he was tutor to the Earl of Kilmarnock—a somewhat remarkable fact so shortly after the '15 when we remember that the Earl's family were Jacobities and Hutcheson a staunch Presbyterian. However, perhaps Hutcheson was not so very staunch. He returned to Ulster in 1719 and was licensed as a probationer, but his preaching was not to the liking of his father's friends. A story is told, indeed, to the following effect. One cold and rainy Sunday, Francis Hutcheson went to preach at Armagh, taking the place of his father who had a cold; but a flickering sun and a determined curiosity took the old man out of his bed and sent him to hear the conclusion of his son's sermon. Instead of that, the unhappy parent met the whole of his flock returning in disgust from the meeting-house. An elder enlightened him. "We a' feel muckle wae for your mishap, Rev. Sir," the elder said, "but it canna' be concealed. Your silly loon Frank has fashed a' the congregation wi' his idle cackle; for he has been babbling this 'oor aboot a gude and benevolent God, and that the souls o' the heathen themselves will gang to Heaven, if they follow the licht o' their ain consciences. Not a word does the daft loon ken, speir nor say about the gude auld comfortable doctrines o' election, reprobation, original sin and faith. Hoot man, awa' wi' sic a fellow."

The truth was that Hutcheson had leanings towards the New Light while his family preferred the old. Hutcheson was cautious, however (or—shall we say?—filial), and he never took sides openly, but was content instead to contribute (anonymously) to the Non-Subscribers at various times throughout his life. He seems to have felt, however, that he had no vocation for the kirk, so he refused the "call" of the congregation at Magherally and founded an Academy at Dublin instead. There he prospered, was bitten with the fashionable philosophical virus of the city, and plunged into authorship. Prosperous as he was, however, two separate complaints were lodged against him in the archbishop's court for daring to teach without a license from the church; and there are indications that Hutcheson would not have objected to joining the Establishment. Still he did not; and Archbishop King (of whom we have already heard) protected his follow-Ulsterman.

His troubles were ended in 1729 when he was appointed a professor in Glasgow. There he had enormous influence. He was principally responsible for the abolition of the old system of regents (who taught everything) substituting the regime of specialist professors. His lectures on the State directed Adam Smith's attention to political economy, and the Kircaldy boy's *Theory of the Moral Sentiments* owes much to his old professor. Moreover, Hutcheson had many other distinguished pupils. For the truth was that he was not only an eminent philosopher and a good organiser but a magnificent teacher. He could speak eloquently, forcibly, and clearly, and this gift, in addition to his personal charm and his liberal opinions, made a deep mark on the literary history of Scotland. The Scottish revival of letters in the 18th century owes as much to this Ulsterman as to any one. When the young Hume was trying to struggle into fame by the publication of his *Treatise* he wrote to Hutcheson for advice concerning the third book on morals. Hume was not a sycophant, and he was the very last of Scotchmen to be reckoned a fool. His action, therefore, was most significant.

Indeed, Hutcheson owes his place in the histories of philosophy quite as much to his personal influence, and to his literary popularity as to the distinctively philosophical merits of his work. In some respects, even, the tale of his work is somewhat disappointing when one comes to examine it. In Glasgow he was too busy to write much, and the books on logic and on metaphysics which he published there (they are only compends or text books) are both eclectic and unsatisfying. He tried to unite the scholasticism he had imbibed at Killyleagh with certain fashionable ideas: and he did not succeed very well. For the rest, it is his moral philosophy that is remembered, and here again there are qualifications. He was in Dublin and only thirty when he published his *Enquiry into the Original of our Ideas of Beauty and Virtue;* his essay on *the Nature and Conduct of the Passions* also appeared during the Dublin period; and his *System of Moral Philosophy* was published posthumously. So the former works are immature and the latter incomplete.

His ethical system, then, cannot be reckoned among the greatest in British philosophy. Philosophically speaking, he improved greatly upon Shaftesbury's moral philosophy, although without the support of Shaftesbury's fatally seductive metaphysics, and he tried, not without success, to develop the psychological side of ethics in the best literary vein. This is a popular procedure to-day—indeed it is the fashion—but the modern philosophers can surround their doctrines with a plausible halo derived from anthropology and the history of human evolution, while Hutcheson could not. What is more, a cool historian must admit that Hutcheson did not appreciate the sceptical tendencies of his moral philosophy (as his great contemporary Bishop Butler did) that frequently he did not perceive the logical consequences of his own doctrine, that Hume and others developed it far more consistently than he did, that Hutcheson often descended (like Lord Kames and others after him) to woolliness scarcely redeemed by illogical piety, and that although Hutcheson was an important figure in the movement which led eventually to utilitarianism his greatness did not lie in his clearheadedness.

None the less, Hutcheson, the man, is a considerable figure in British philosophy. It has been claimed for him that he was one of the founders of the Scottish school, but this is a mistake. He builds upon human nature, as Reid did later, but he gives in essence and even upon the surface a very different account of human nature from Reid's. The impetus which he gave to philosophy lay rather on the side of psychology and of the literary aspects of philosophy: but it is no mean thing to succeed in this enterprise. Scotland needed a renaissance, and therefore she owed much to Hutcheson.

And Hutcheson's influence was not confined to Scotland. To Dublin in his early years he brought an Ulster leaven, and he remembered the interests of Presbyterian Ulster in Glasgow. Hutcheson's letters to Dr. Drennan of this city show a constant solicitude for the Ulster youths under his charge. And some of them needed it. "I am deeply mortified by the vanity and foppery prevailing among our countrymen," Hutcheson writes, "beyond what I see in others; and a sauntering forsooth which makes them incapable of any hearty drudgery at books." As one of the culprits he particularly mentions was the son of a non-subscribing minister in Belfast, this comment perhaps is scarely what one would expect. The rowdiness of the Ulstermen of which we hear from other Glasgow sources seems more natural somehow. Reid later had a great deal of trouble with the "wild Irish Teagues," as he call them—those Ulster Protestants whose natural university was Glasgow.

In course of time, however, Belfast began to want a university of its own, and the Academical Institution (which included a college) was founded in 1815. Two philosophers, both of them Scottish seceders, were imported from Glasgow —one of them, John Young; the other, William Cairns. Cairns published a book on *Moral Freedom* in 1844, and Young's lectures were published posthumously under the title "*Lectures on Intellectual Philosophy.*" This book (I hope I am not offending any of Young's descendants) gained the following unenviable notice from Sir William Hamilton, "This unfortunate speculator seems to have been fated in almost every instance to be anticipated by Brown; and as far as I have looked into their lectures I have been amazed with the never-failing preamble—of the astonishment, the satisfaction and so forth, which the author expresses on finding, on the publication of Brown's *Lectures*, that the opinions which he himself, as he says, had always held and taught, were those which had obtained the countenance of so distinguished a philosopher. The coincidence is, however, too systematic and precise to be the effect of accident; and the identity of opinion between the two doctors can only (plagiarism apart) be explained by borrowing from the hypothesis of a pre-established harmony between their minds." Later, however, Hamilton added a footnote. "I now find, and have elsewhere stated, that the similarity between these philosophers arises from their borrowing, I may say stealing, from the same source—De Tracy."

After the Queen's College was founded in Belfast, Clarendon the Lord Lieutenant of the day was so much impressed by the merits of a book entitled *The Method of the Divine Government, Physical and Moral* that he appointed its author, a Brechin minister called James M'Cosh, to the Professorship of Logic and Metaphysics in the year 1857. This appointment prompted Thackeray's lines "The Last Irish Grievance," from which I quote some stanzas. Thackeray speaks in the person of an Irish youth.

As I think of the insult that's done to this nation
  Red tears of rivinge from me faytures I wash,
And uphold in this pome, to the world's daytistation
  The slaves that appointed Professor M'Cosh.

I look round me counthree, renowned by expayrience,
  And see midst her children, the witty, the wise—
Whole hayps of logicians, potes, schollars, grammarians,
  All ayger for pleeces, all panting to rise.

I gaze round the world in its utmost diminsion,
Lord John and his minions in Council I ask,
Was there ever a Government pleece (with a pinsion)
But children of Erin were fit for that task?

On the logic of Saxons there's little reliance,
And, rather from Saxon than gather its rules,
I'd stamp under feet the base book of his science,
And spit on his chair as he taught in the schools.

O false Sir John Kane! is it thus that you praych me?
I think all your Queen's Universitees bosh;
And if you've no native professor to taych me
I scawurn to be learned by the Saxon M'Cosh.

M'Cosh remained in Belfast for the next seventeen years, and then went to Princeton (of which celebrated university he was president). It was in Belfast, however, that his most important books were written and his considerable reputation consolidated. It is not quite fair to discuss his philosophy nowadays. Some of his ideas, it is true, are now more fashionable than they were twenty years ago, but they are not very likely to recur in the form in which he put them, and he was neither eminent enough nor enough of a pioneer to make it likely that future historians of philosophy will honour him with more than a footnote.

On the other hand he was certainly a very clear writer, and a most assiduous and successful teacher. I have met many of his pupils here, and they all concur in this verdict. I have no doubt, indeed, that some of my audience here can vouch for the fact from personal experience. On this account chiefly I do not propose to say more about M'Cosh now. A historian is more comfortable when he is dealing with remoter persons and events, and this consideration restrains me even more forcibly from dealing with Ulster philosophers who are either alive or who have died only recently. I think, for example, of William Graham or of J. J. Murphy, President of the Linen Hall Library for twenty years and author of *Habit and Intelligence* and of other works: or of my predecessor, John Park, and I am silent. I shall only venture on one tiny phophecy. At last, after an interval of centuries, the philosophers of England are beginning to construct what the Germans call a *natur-philosophie*, and I venture to predict that when our grandchildren come to estimate the origin of this movement in twentieth century Britain, they will unanimously place the name of Mr. A. A. Robb very high.

One other reflection and I have done. The influence of Ulster in philosophy, as in everything else, cannot be limited to the work of those who have been born or who have long resided within her borders. Her children and their descendants beyond the seas must also be counted to her credit; and I confess that I conceived the idea of writing this lecture when I read the recently published *Letters* of William James. James was a delight to the world, and Ulster gave him. James's paternal grandfather—also William by name—went to America from the town of Ballyjamesduff, in County Cavan, in 1789. He arrived with very little money and a latin grammar, founded the salt industry of Syracuse and amassed so considerable a fortune as to be able to bequeath a comfortable inheritance to his widow and to each of his eleven children. "When old Billy James came to Syracuse," the customary old inhabitant said, "things went as *he* wished."

Therefore James was an Ulsterman by descent on his father's side, and his mother's forbears were also Ulster people. His mother was descended from a certain Hugh Walsh who came from Killingsley (?), Co. Down, according to James's *Letters* (Killyleagh, according to Henry James), in 1764. All honour then to the province that gave us William James.

10th January, 1922.

Henry Riddell, Esq., M.E., M.I.Mech.E., President, in the Chair.

" COMETS."

By Rev. W. F. A. Ellison, M.A.

[*No Abstract.*]

16th January, 1922.

Henry Riddell, Esq., in the Chair.

" MOLIÈRE."

By Professor Savory, M.A.

[*No Abstract.*]

14th March, 1922.

Henry Riddell, Esq., M.E., M.I.Mech.E., President, in the Chair.

" DRENNAN AND HIS TIMES: FOUNDED ON FAMILY LETTERS."

By Alexander Riddell.

[*No Abstract.*]

31st January, 1922.

HENRY RIDDELL, M.E., M.I.Mech.E., President, in the Chair.

"THE USE OF PHOSPHATES IN AGRICULTURE."

By G. S. ROBERTSON, D.Sc., Head of Chemical Research Division, Ministry of Agriculture, Northern Ireland.

Agricultural science began in the Nineteenth Century. In the opening decades the important fact was established that there are three fertilising elements which must be applied to the soil in order to maintain its fertility, and in order that increased crops may be obtained. They are Nitrogen, Phosphates, and Potash.

The future of agriculture in this and every other country, to a very large extent, depends upon the manufacture of these three groups of fertilisers in suitable forms, and in adequate quantities.

Few realise that agriculture has progressed so rapidly during the past 80 years that to satisfy the requirements of the industry for artificial fertilisers large chemical industries have been created, necessitating in many cases the establishment of new towns and cities.

The problem associated with the supply of nitrogenous fertilisers has been solved by the discovery of methods for utilising the nitrogen of the air. To-day over 4½ million tons of nitrogenous fertilisers are manufactured annually from the nitrogen of the air; the total value being in the neighbourhood of 45 million pounds.

We are not, however, in such a happy position with regard to our supplies of phosphates. It would be difficult to say when phosphates were first used in agriculture. As far back as we can go they seem to have been used in the form of bones, which we now know contain in the dry state from 60 to 80 per cent. of phosphate of lime.

It was not, however, till 1800 that Lord Dundonald established the fact that bones owed their value to the phosphates which they contained, and not, as was then thought, to their oil or fat content.

From 1800 onwards the use of bones in agriculture grew with great rapidity. The home supply became inadequate, and we began to import in very large quantities.

About 1834, Lawes—the first English agricultural chemist—patented a process for dissolving bones in sulphuric acid and thus making the phosphate soluble in water. Hitherto bones had been simply broken into small lumps and ploughed or rolled into the soil. In such a form they were very slow in their action, and could be ploughed up after the lapse of several years apparently unaltered. Lawes' dissolved bones, or bone super-phosphate, contained phosphate soluble in water, which when applied to the soil could be immediately utilised by the young plant. So effective was it in its action that it gave a great fillip to the search for bones and England began to ransack the whole of Europe for supplies. So keen was the competition that even the battlefields of Leipsic and Waterloo are said to have been turned over in the course of the search.

The situation was eased by the discovery of large deposits of rock phosphates in Spain, North Africa, the United States, and certain of the Pacific Islands, and Lawes was able to continue making his superphosphate by dissolving these ground rock phosphates, which were found to contain from 50-80 per cent. of phosphate of lime.

For the next forty years or so the use of Lawes' superphosphate grew rapidly, and as there seemed to be no limit to the amount of raw rock phosphate which could be obtained no anxiety was felt with regard to our supplies.

In 1878 a new type of phosphatic fertiliser appeared, namely, basic slag, and it was the means of connecting agriculture with our great modern steel industry.

Steel is made from "Pig iron," which in turn is made from iron ore. Our most important deposits of iron ore occur in the Cleveland district of the North Riding of Yorkshire. These iron ores contain phosphorus, and it was not at first possible to manufacture steel from them because the phosphorus passed into the steel, rendering it brittle and unfit for industrial purposes.

This difficulty was overcome by two steel chemists, Thomas and Gilchrist, who devised a process for removing the phosphorus. They lined the steel furnace with lime, and also charged lime into the furnace along with the pig iron. The lime passing through the molten metal combined with the phosphorus, forming phosphate of lime. This, together with the excess of lime and other impurities, floats on the top of the molten metal at the end of the boil as a scum or slag. The slag, being lighter than the molten metal, is removed by pouring, and on cooling sets into a hard, rock-like mass.

Ground to a fine powder, so that 80-90 per cent. will pass a sieve with 10,000 holes to the square inch, this waste product from the manufacture of steel by the Basic Bessemer process became the basic slag so highly prized by the agricultural community. It contained about 40 per cent. of phosphate of lime.

At first basic slag was considered to be of little value, because the phosphates were insoluble in water. Various attempts were made to dissolve the slag in sulphuric acid, and so obtain a water soluble phosphate, but the attempt was abandoned as uneconomical and impracticable.

Two agricultural experimentors, Prof. Wrightson and Mr. Munro, persuaded some of the steel manufacturers to grind some of the waste slag to a fine powder. They applied it to grass land, and obtained highly-successful results.

These results were amply borne out by experiments in other parts of the country, particularly at Cockle Park, and the foundation was laid for the big basic slag industry.

Last year the British farmer used no less than half a million tons of the fertiliser.

THE PRESENT POSITION.

Unfortunately for the farmer, changes in the manufacture of steel began to take place about 1912, and these changes were hastened by the conditions resulting from the war.

The new process of steel manufacture enabled the steel maker to produce his steel more economically; but, alas for the farmer, it meant a slag containing only half the quantity of phosphates (20 per cent. instead of 40 per cent.), and one in which the phosphates were much more insoluble than previously.

The farmers of the United Kingdom are now faced with a possible supply of only 40,000 tons per annum of high-grade slag instead of 400,000 tons.

The agricultural significance of the change is apparent from a consideration of the figures in the following table:

TABLE I.

Production of Basic Slag in 1920.

	Grade.	Tons.
1.	Over 33% phosphate	46,300
2.	26 to 33% ,, ...	121,400
3.	22 to 26% ,, ...	90,900
4.	15 to 22% ,, ...	302,500
5.	11 to 15% ,, ...	118,000
6.	Under 11% ,, ...	22,000
		701,100

It is exceedingly doubtful whether grades 4, 5, and 6 can be profitably marketed on account of their low phosphate content. The available supply is thus only about 160,000 tons, whereas the demand, which is steadily increasing, is approximately 500,000 tons.

It has been estimated that the farmers in Great Britain and Ireland could use with advantage to themselves and the community 33,820,000 units of phosphate in the form of basic slag, equivalent to 850,000 tons of high grade basic slag containing 40 per cent. of phosphate. If all the basic slag containing 15½ per cent. of phosphate and upwards could be used the available supply would only be 13,400,000 units of phosphate, leaving a deficiency of 20,420,000 units, equivalent to 510,500 tons of basic slag containing 40 per cent. of phosphate.

It is a matter of great importance to find a substitute for basic slag, because we now know there are certain soil conditions for which superphosphate is not the most suitable phosphate to use.

With this object in view, experiments have been conducted during the past few years with raw ground phosphates, mined in North Africa, to ascertain whether if they are finely ground they can take the place of basic slag.

The results from some of these field experiments are set out in a condensed form in Table 2.

TABLE II.

ESSEX EXPERIMENTS WITH VARIOUS PHOSPHATES.

WEIGHT OF HAY IN CWTS PER ACRE—PLOTS ¼ ACRE IN AREA.

Type of Phosphate	Tysea Hill Farm Average 4 years	Martin's Hearne Farm Average 5 years	Horndon	Saffron Walden Average 5 years	Butterfield's Latchingdon Average 5 years	Lambourne End Average 3 years
Basic Bessemer Slag (old process slag)	30.9	27.2	26.0	40.9	29.4	30.3
Open Hearth Fluorspar Basic Slag (new process slag)	—	21.3	16.8	—	—	29.9
Untreated ...	20.3	16.1	5.6	30.4	20.5	17.7
Gafsa rock Phosphate	30.5	27.6	22.2	38.1	27.3	—
Egyptian do	—	24.1	24.3	—	—	26.6
Algerian do	—	25.3	20.1	—	—	—
Tunisian do	—	—	23.5	—	—	30.3
Florida Pebble Phosphate	—	—	15.8	—	—	28.4

The plan followed in the above experiments was to give each plot exactly the same amount of phosphoric acid (200 lbs. per acre), the only difference being the form in which it was applied. Only one dressing was given and no other artificials were applied. The hay crop on each plot was weighed for four or five years in succession.

It is quite clear from the results that in some soils—particularly on grass land—ground rock phosphates are capable of giving as good, and sometimes better, results than the best grades of basic slag.

At one of the centres given in the above table—Horndon—the experimental plots were grazed during the season of 1919 instead of being reserved for hay. The plots, unfortunately, were not big enough to permit of grazing trials, but as the differences in the botanical composition of the untreated plots and the plots receiving the various phosphates were so striking, a method was devised for determining the percentage of the ground space occupied by the various species. The results are set out in table 3.

TABLE III.

PERCENTAGE OF THE GROUND SPACE OCCUPIED BY THE VEGETATION ON THE PLOTS AT HORNDON

Phos. No.	Type of Phosphate	Clover %	Grass %	Weeds %	Bare Space %
3	Algerian with Phosphate	47.4	30·1	7·4	15·1
5	Basic Slag (old process)	44.1	28·6	13·7	13·6
6	Untreated	4.2	14·8	31·0	50·0
8	Gafsa with Phosphate	41.3	32·3	17·6	8·8
9	Tunician do	38.5	36·9	21·0	3·6
12	Egyptian do	55.5	41·0	0·7	2·8
16	Untreated do	9.4	19·1	26·0	45·5
18	Basic Slag (new process)	43.8	31·8	13·3	11·1

The contrast between the figures for the untreated plots and the plots receiving phosphates is very striking indeed. It will be noted that the various phosphate have brought about a revolution in the botanical composition of the herbage, and that in this respect the various types of phosphate appear to be equally efficacious. The bare space has become filled in with clover and so vigorous is its growth when supplied with suitable phosphates that it is able to crowd out the weeds to a very large extent. The appearance of three of these plots is illustrated in Figs. 1, 2, and 3.

Experiments which have recently been made in the North of Ireland confirm the results recorded above. Further experiments, which, it is hoped, will throw considerable light on the problem raised, are in progress under the auspices of the Ministry of Agriculture for Northern Ireland.

The Future.

It is very probable that in the near future we shall be dependent for our supplies of phosphates upon the deposits of rock phosphates. The farmer may have these phosphates in two forms:—

(1) Dissolved in sulphuric acid as superphosphate in which the phosphate is soluble in water. This is the quickest acting type of phosphate available.

(2) Finely ground, in which form it is hoped it may take the place of basic slag which we know is more suitable to certain types of soil than superphosphate.

At present 8 million tons of these ground rock phosphates are being mined annually for agricultural purposes. It is certain that the world's requirements will increase with great rapidity, and it is no exaggeration to say that the agricultural prosperity, and therefore the industrial prosperity, of the various countries will be determined in the future by the supplies of phosphates which they can secure. In this respect the British Empire is badly off. The United States has already taken steps to conserve its supplies, France has control of the North African deposits—the largest deposits in the world; whilst, with the exception of the deposits on Nauru and Ocean Island, the sources of supply within the British Empire are, as far as we know, insignificant.

Just as in the past, we have seen a struggle for oil supplies, in view of the fact that oil was to play a determining part in industrial supremacy, so at the present moment we are witnessing a keen competition amongst the world powers for phosphates, because there is every prospect of such supplies becoming of vital importance in the future.

7th February, 1922.

Henry Riddell, M.E.,M.I.Mech.E., President, in the Chair.

"SOME PRODUCTS OF WOOD WASTE."

By W. H. Gibson, O.B.E., D.Sc., F.I.C., F.Inst.P.

ABSTRACT.

The industry of Wood Distillation goes back to very early times, though the ancients only sought the charcoal obtained. In England in the Middle Ages there were large forests in the southern counties, and this was a manufacturing district. The timber was used for building and for the construction of ships, while the waste material was used partly as fuel and partly to obtain the charcoal wanted for iron-smelting.

Charcoal-burning in the old-fashioned way still goes on in remote districts in Russia and Finland. The wood is piled round a narrow central shaft, and the mound is covered with a layer of charcoal and earth. The heap is lighted in the middle at the bottom. Part of the wood burns away, but as the access of air is closely restricted combustion is not complete, and the most of the wood is converted into charcoal. When the charring is complete the kiln is allowed to cool down before exposure to the air, as it would otherwise burst into flame.

The next development lay in constructing the kiln with a small well underneath the base of the pile, into which tar could run. The smoke from burning wood in a restricted air supply contains several different gases, with a quantity of tar and an acid vapour consisting mainly of acetic acid, the basis of vinegar. The desire to recover these products led to the construction of more elaborate kilns, resembling

Fig. I.- Basic Slag Plot at Horndon. August 1919.

Fig. II.—Gafsa Rock Phosphate Plot at Horndon. August, 1919.

Fig. III.—Untreated Plot at Horndon. August, 1919.

The Society is indebted to the University Press, Cambridge, for permission to reproduce Figs 1, 2, and 3 from the monograph by Dr. Robertson on "Basic Slags and Rock Phosphates."

brick ovens with pipes carrying off the products for condensation with water. These were replaced by retorts something similar to those used in the manufacture of coal gas, and with this type of apparatus we reach modern conditions.

To understand the use of such retorts it is necessary to have at least a rough idea of the chemical nature of wood and the reaction that takes place during the distillation.

Wood is essentially composed of the three elements carbon, hydrogen, and oxygen, the approximate analysis being: carbon, 50 per cent.; hydrogen, 6 per cent., oxygen, 44 per cent. There are two main constituents in wood, cellulose and lignin. Cellulose is known in a very pure form in cotton, and has a composition of carbon 44 per cent., hydrogen 6 per cent., oxygen 50 per cent.; while lignin is richer in carbon and poorer in oxygen. Both these substances are very complicated in nature, and their construction is not yet unravelled. Cellulose, however, seems to be closely related to grape sugar, and formulæ have been suggested with molecules of grape sugar linked up in various ways. The main product of the distillation of cellulose is charcoal, about 39 per cent.; accompanied by water, 34.5 per cent.; tar, 4 per cent.; acetic acid, 1.5 per cent.; and a considerable volume of gas amounting to a proportion of carbon dioxide 10 per cent. and carbon monoxide 4 per cent.

The effect may be broadly described as the removal of water, accompanied by charring and evolution of carbon dioxide gas, the tar and acetic acid being by-products.

The lignin gives in addition methyl alcohol, or wood spirit, so that it is on the proportion of lignin that the yield of wood spirit depends. Lignin is also the principal source of the tar, yielding about 13 per cent. of this material.

The proportions of lignin and cellulose largely determine the products given by distillation, and these proportions vary considerably in different trees, changing with the age of the tree and differing in heart and in sap-wood. The age of the tree affects also the nature of the charcoal, young wood containing more sap and giving inferior charcoal, while very old wood gives charcoal which splits readily and causes loss in transport. The time of year in which the trees are felled is of importance, winter felling giving less sap and better results in distillation. The quantity of moisture present is extremely important, and it is usual to store the wood for six months or more, when a fairly constant figure of 20 per cent. is obtained. This enables more regular results to be obtained.

In the process of distillation, starting from cold up to a temperature of 270° C., the water contained in the wood is first driven off, accompanied by gases which are mainly oxides of carbon, but as soon as the critical temperature is passed the nature of the gases changes completely, the oxides of carbon diminishing and being replaced by hydrocarbons, methane, etc. The quantity of aqueous distillate also diminishes; the gases are drier; the quantity of tar increases and its nature is more viscous. Up to 270° C. the apparatus requires external heat, but from this temperature the charring proceeds with practically no external heating, the reaction becoming exothermic, the decomposition spontaneous. Up to a temperature of 500° C. the evolution of hydrocarbon gases increases, while at a higher temperature the hydrocarbons are replaced by hydrogen. In practice the carbonisation is stopped and the process finished at 380° to 400° C. If the process is stopped at 400° C. and the retort closed a further formation of hydrocarbons occurs while cooling is going on, and oxides of carbon and hydrogen gradually disappear. When retorts in which the charcoal is kept to cool are closed during this stage the pressure rises and the gases inside the retort become 80 per cent. to 90 per cent. hydrocarbons. This pressure gradually disappears as the charcoal absorbs the gaseous hydrocarbons, with formation of solid varieties, the carbon content increasing in the charcoal by 5 per cent. to 6 per cent.

On the commercial scale of distillation all the stages mentioned may be taking place at the same time in the one retort, as the large size of the apparatus does not allow uniform transmission of heat to all the wood in the vessel. Some of the wood near the heating surface may be in the final stage, while part further removed from the source of heat may be only beginning the reaction. The nature of the products can be influenced by the method of heating the retort and by the temperature of the furnace, a high temperature and rapid working giving much gas and less acetic acid, wood spirit, and charcoal. The design of the retort used will also influence the results. In small retorts the radiation from the heated sides is sufficient to keep the internal temperature differences small, but this is not the case with the large American and Swedish retorts. With vertical retorts delivering downwards the layers at different levels will be at different stages. When any considerable portion of a charge reaches the exothermic stage it supplies to the remainder so much heat that this portion is brought with a rush to the distillation stage. There is consequently a period of violent and copious evolution of gas and distillate which extends over one to six hours, according to the size of the vessel.

The practical divisions of the process on the commercial scale are:—

1. Simple evaporation of water, almost without gases up to 170° C.

2. Water vapour, oxides of carbon, and some acetic acid up to 270° C.

3. The exothermic stage, or spontaneous period, with copious and even violent evolution of gases, hydrocarbons, acetic acid, wood spirit, and tar.

4. A gentler distillation until a temperature of 400° C. is reached.

5. The period of cooling, with re-absorption of gases by the charcoal.

The first two periods require external heat, but the third gives out heat and yields the most useful combustible gases. Arrangements must therefore be made for a rotation of work in a number of retorts, that these gases given out in the third stage may be applied to heat the retorts at the initial stages of the process. The lower the temperature in the first period and the slower the addition of heat at the beginning of carbonisation, the greater the quantity of the dried wood in the retort and the more violent the action in the third period.

As the reaction after the wood reaches 270° C. is so rapid the method of firing is such as to prevent complete drying of large masses at the same time; the drying and the carbonisation must be run together. This is naturally more difficult with large retorts. The condensation arrangements must be planned to cope with the rush of the vigorous periods by a joint condensing system for several retorts, the heavy demand of each coming in turn.

The final temperature regulates the composition of the charcoal obtained.

Wood differs much in composition, even when taken from the same tree; it varies in water content, in proportions of cellulose and lignin, in the porosity or the soundness of the wood; and these differences are such that the results of any two distillations are never exactly alike. The skill or attention of the stoker is also a considerable element in the final result.

A description of the use of a small retort system often used in Germany will enable the process to be better understood.

Two horizontal iron cylinders, each about ten feet long by three feet six inches in diameter, are embedded in masonry, having a furnace between them, and arrangements permitting the circulation of the hot gases from the fire around the retorts slowly to carbonise the charge of wood. There is a wide tube connecting each retort to a tar-separator, followed by a coil of copper tubes cooled by a water tank and acting as a condenser for the watery distillate. The uncondensed gases pass a water seal and then return to the furnace to be burnt. In the continuous use of such a plant the charcoal is removed as soon as the operation is finished, and rapidly emptied into a kind of iron box, which is closed air-tight, and in it the charcoal is allowed to cool. As soon as the charcoal is thus removed the retorts are refilled with billet wood, closed up, and the fire applied. Within ten minutes the neck of the retort warms up, then the first distillate begins to pass, accompanied by carbon dioxide and nitrogen from the air present. Almost at once this is replaced by a mixture of carbon dioxide and carbon monoxide, and the distillate becomes acid, showing that the wood touching the hot sides has reached the temperature of carbonisation. The quantity of uncondensed gases increases, as does also the acid content of the brown aqueous distillate, with a darkening of its colour through the increase in quantity of tar, while the oxygen containing gases give place to hydrocarbons and hydrogen. At last the gas evolution weakens, and the cooling of the retort neck indicates the completion of the process. The fire is removed, the door opened, the charcoal removed, and the work begins again.

This dry distillation yields from deciduous trees:

1. Wood gas, of which the combustible portion is utilised in the furnace.

2. A brown watery liquid, wood vinegar, containing

3. Wood tar, partly dissolved and partly in suspension.

4. Wood charcoal.

When pine wood is being used there is also given off:

5. A product floating on the wood vinegar, consisting of terpenes, products of the dry distillation of resinous substances.

Typical yields from 100 parts of dry wood are:

Beech—Charcoal, 30 per cent.; acetate of lime, 8 per cent.; wood spirit, 2 per cent.: tar, 6 per cent.

Pine—Charcoal, 30 per cent.; acetate of lime, 2½ per cent.; wood spirit, 0.4 per cent.; tar, 20 per cent.; and turpentine, 8 per cent.

The lime acetate is obtained by neutralising the acid liquor with lime. The gases consist of about 60 per cent. carbon dioxide, 33 per cent. carbon monoxide, and about 6 per cent. of hydrocarbon gases and hydrogen. At the vigorous period the composition is about as follows:—Carbon dioxide, 36 per cent.; carbon monoxide, 48 per cent.; and hydrocarbon gas, 16 per cent. It is desirable to keep the quantity of gas as low as possible by keeping down the temperature of carbonisation, to recover a greater quantity of the methyl alcohol or wood spirit. The heat value of the gases thus derived from one hundred tons of wood is about equivalent to three tons of coal.

There are some inconveniences and disadvantages due to the small size of such apparatus, and these are removed by the use of a later development, the modern oven. This is much used in America, from which the greater part of the supply of charcoal and wood spirit is derived. It takes the form of an iron tunnel fifty or sixty feet long, through which runs a light railway, which takes the trucks containing the wood. Five or six of these, containing about ten tons of the billet wood, are run into the tunnel by the entrance end, the iron doors are closed, and the heat from the furnace below the tunnel starts the reaction. Above the iron tunnel is a brick floor for drying the acetate of lime, while pipes lead from the top to condensers in the manner already described, the condensers being at the side of the plant. When the distillation is finished the iron door at the other end is opened, and the locomotive drags out the trucks and carries them into another iron tunnel, where they are closed up for cooling. As they cross the few feet of space between the two tunnels the charcoal breaks out into flame, but the cooling tunnel is airtight and the flames do not last. It is usual to have a third tunnel, a second cooler, into which the trucks are removed at the next changing time. From this second cooler it is taken to the store, where the charcoal is bagged and sent away. The raw distillate is allowed to settle in large wooden vats to separate the tar.

In such a factory a large area is covered by stacks of wood in process of air drying, sawmills for reducing the wood to billets, stores, redistilling houses, and other buildings.

A further development of plant is found in the Grondal, or Swedish, system. Here the trucks pass through a heated central chamber and are admitted and sent out one at a time. By this means a constant heat is maintained, the different stages being in operation at the same time. The retort takes the form of a masonry tunnel about 220 feet long, divided into chambers by iron doors. The entrance compartment is about fifteen feet in length, the charring chambers about one hundred and thirty-five, the cooling chamber about fifty-five feet, and the exit compartment fifteen, all being separated and closed by iron doors. The heat from the furnace gases is supplied by iron flues. The volatile products escape from pipes in the roof, and are condensed as usual, while the tar drips on the floor and is led to tanks by pipes. One truck is pushed in at the entrance chamber, the outer door shut, and all the internal doors open so that the trucks are all moved forward one length, thus releasing one truck at the exit chamber. This is repeated about every hour.

The destructive distillation having been completed, the products require to be isolated. The wood vinegar contains from ten to twenty per cent. of soluble organic compounds, say three per cent. of wood spirit and eight per cent. acetic acid. A few of the substances found may be named:—

Acids — Formic, acetic, propionic, butyric, valeric, caproic.

Alcohols—Methyl, allyl.

Aldehydes—Acetaldehyde, furfurol, methyl furfurol.

Ketones—Acetone, methyl-ethyl ketone, ethyl-propyl ketone.

Acetals—Methylal, dimethyl acetal; with ammonia and amines.

The tar contains a whole series of hydrocarbons and phenols. As the weak liquor cannot be profitably transported it is necessary to separate the substances of value at the works. Acetone boils at 56° C., wood alcohol at 66° C., water at 100° C., and acetic acid at 120° C. Fractional distillation is used to separate the acetone and wood alcohol from the water and acetic acid, when the latter is neutralised by lime and recovered as calcium acetate. Owing to the presence of so many reactive substances, such as aldehydes, ketones, phenols, and amines, a troublesome condensation product is obtained called "blister tar." Unless this is removed it remains mixed with the acetate. This crude brown mixture contains only about sixty per cent. of calcium acetate. The crude liquor is allowed to settle in tanks, when tar separates. This is the useful tar which can be worked up. The clear, settled liquor is then distilled in a copper still, when the wood spirit and wood vinegar pass over, leaving the resinous "blister tar," which is practically useless. It is either burnt direct, or redistilled to get from it the last remnant of acetic acid, of which it has retained about eight per cent. The liquor is then neutralised with slaked lime and distilled to remove the wood alcohol. The acetate is evaporated further in a multiple effect evaporator, then transferred to open tanks above the retorts, and when it reaches the pasty stage is spread on the drying-floor to dry. In some modern factories the pasty acetate is taken up from the tank by a steam-heated drum, drying rapidly, and being removed by a scraper at another part of the revolution.

The wood spirit liquor left after removing the acetate is run through a continuously-acting fractioning still, where it is completely freed from the spirit, which is again separated into two fractions, of which the more volatile is a crude acetone, containing methyl acetate and other organic liquids. This is run to storage tanks. The second fraction collected is wood spirit, about 82 per cent. methyl alcohol, removed at another level. This is refractioned to about 98 per cent. The tar is used as a wood preservative, or distilled, the pitch being removed and creosote being formed, which is used for curing processes and as an antiseptic.

Wood spirit is used for denaturing alcohol, as a solvent for varnishes and resins, and in the manufacture of formaldehyde, which is used as a preservative and disinfectant, as well as being a starting point for the manufacture of many valuable chemicals and dyes.

The acetone fraction, generally called methyl acetone, is used in many industries as a solvent for collodion, or cellulose acetate.

The calcium acetate is used to make acetic acid by reaction with sulphuric acid and distillation. The uses of acetic acid are many. It is the basis of vinegar, which is often only a solution of acetic acid thus made, with colouring and flavouring matter sometimes added.

The acetates are useful salts; for example, aluminium acetate is much employed in dyeing and calico printing. The water-free or glacial acetic acid is used to convert cellulose into cellulose acetate, which is the basis of one type of artificial silk, and when dissolved into varnish is used for varnishing aeroplane wings and is known as dope.

Another derivative is the valuable drug aspirin, in whose manufacture the acetic acid is used. It is acetyl salicylic acid. From acetate is also derived the very important acetone.

These derivatives are often obtained at the wood distillation works, acetone, for example, being obtained from the acetate by a process of destructive distillation, in which it is heated to a temperature between 300° C. and 400° C., leaving $CaCO_3$ behind. Acetone is about the best solvent for nitrocottons, and is used in the manufacture of celluloid and cordite. It is the starting point for the manufacture of chloroform and iodoform. Sulphonal is also derived from acetone.

Perhaps enough has been said to show that a process apparently so simple as the destructive distillation of wood is, when translated into the industrial scale, a most elaborate and complicated business, and that, although the products are valuable, the industry is remarkably dependent for success on favourable conditions. It is therefore possible that this method of disposal of wood waste will not survive indefinitely. Some of the larger pieces of waste may be worked up into small articles, broom and brush heads, toys, etc. A cheap source of wood is necessary for the development of a toy industry. Larger articles may be built up in laminated structure, as was done for aeroplane propellers, and possibly may be applied in many other ways. When suitable glues are used the built-up article is stronger and less liable to warp than a solid one. Small pieces are converted into wood wool by a machine which cuts them into fine curly threads, much used for packing purposes. Wood waste may also be converted into wood pulp for paper manufacture, but at present the immense demand for this material leads to the sacrifice of whole forests. As a fuel wood waste is, of course, used in woodworking factories. As a source of heat it has about half the value of the same weight of coal. In Sweden wood waste mixed with coal has been used for the generation of town gas, and in woodworking factories in this country and elsewhere it is often used for the generation of producer gas for power purposes, as much as 35,000 cubic feet per ton of wood being generated, of a thermal value of 340 B. Th. U.

Much work has been done in the endeavour to convert wood waste into alcohol, but commercial results have not been obtained. The process depends on the intermediate production of grape sugar, and a good yield of this substance can only be obtained at present by the use of strong acids, which renders the process too costly. It is, of course, possible that an economical conversion process may be discovered in the near future, when the great potential value of alcohol as a substitute for petrol would allow an immense development.

The products we now obtain by the destructive distillation of wood may have in the future to fear competition from synthetic methods. Acetic acid, the main product other than charcoal, has been made from acetylene, while acetone has been got by the fermentation of starch with a special culture of bacteria—a process considerably developed during the war.

There is no finality in scientific work, and processes accepted as standard in one generation are obsolete in the next. Scientific research is being applied to many industries that formerly were content to depend upon traditional methods, so that we may expect the coming age to be one of great industrial changes, in which old industries will go and new ones arise. The processes described must certainly go unless improvements in methods are effected to reduce the waste. In the American forest trade only 25 per cent. of the timber cut is obtained as finished lumber, and the waste in making wooden articles from this lumber varies from 30 per cent. to 65 per cent. Waste has arisen because of the large quantity of wood available, but this supply is becoming restricted, and the necessity of economy will be driven home. In the conversion of wood too much is done by mere rule of thumb. Chemical investigation will assist in the utilisation of vast quantities of waste, perhaps for purposes now totally unsuspected. For example, there have already been several methods suggested for the conversion of sawdust into cattle food. Even in the process of distillation described more careful investigation and attention to detail may lead to considerable economy. The rapid decrease of forest area within reach of transport facilities will compel this attention to be given, and large economy must somehow be obtained if the industry is to survive.

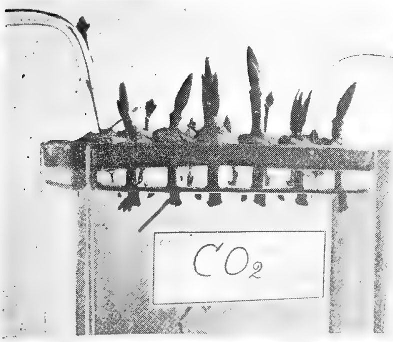


FIG. 1

FIG. 2

FIG. 3

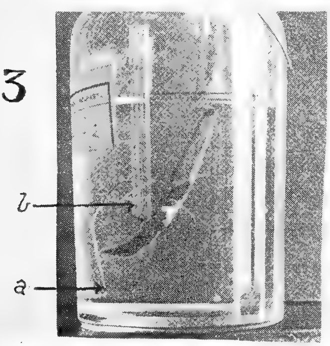
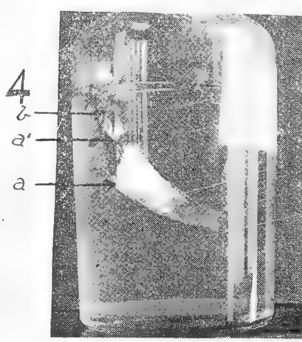


FIG. 4



EXPLANATION OF PLATE

Fig. 1. Six cuttings of *Aucuba japonica*, treated with carbon dioxide, showing two with roots and four other callused. Started 23rd November, 1921. Photographed 16/2/22. Oak cuttings in back-grounc

Fig. 2. Six cuttings of *Aucuba japonica*, treated with air, show ng one with roots and two others callusec Started 23rd November, 1921. Photographed 16/2/22 Oak cuttings in back-ground.

Fig. 3. Half of a leaf of *Bryophyllum calycinnm*, treated with carbon dixoide ; *a*. tip of one of the lon roots ; *b*. translucent leaf of etiolated shoot.

Fig 4. Other half of same leaf, treated with air ; *a*. tips of short roots ; *á*. tops of short roots ; *b*. stem c normal shoot. The bottles in Figs. 3 and 4 were filled up with water for photographing purpose:

Friday, 24th February, 1922.

HENRY RIDDELL, M.E., M.I.Mech.E., President, in the Chair.

JAMES SMALL, D.Sc., F.L.S., M.R.I.A.,
Professor of Botany, Queen's University, Belfast.

MORE ABOUT THE ERECTNESS OF PLANTS.

It has been established since 1806 that the influence of gravity is the usual cause both of the upward growth of the shoot and of downward growth of the root. The region in the root, which is sensitive to gravity, has been shown to lie at the extreme apex, while the region of actual curvature lies a few millimetres up from the root-tip, coinciding with the region of greater growth. It has further been shown that in many cases the shoot has similar regions of sensitiveness at the tip and of curvature lower down, although the stem frequently exhibits sensitiveness for the larger part of its length, especially in seedlings. Since the beginning of the present century gravity has been generally considered to act on root and shoot by displacing certain loose starch grains or other movable heavy bodies in the cells of the sensitive region. The puzzle of the opposite directions given to root and shoot by this apparently uniform cause has, however, remained.

In the previous lectures on the erectness of plants * a theory was given which accounts for this difference of direction and some experiments were described, the results of which are in accordance with that theory.

*See Proc. Belf. Nat. Hist. & Phil. Soc., 1920-1921, p. 91 sqq.

The theory as originally stated may be briefly summarised as follows:—Protein-fatty particles, suspended as an emulsion in the cell, carrying an electropositive charge in the root and an electronegative charge in the shoot, were supposed to cream upwards in the cells which are sensitive to gravity. This creaming of charged particles was then supposed to give rise to electric currents flowing in a more or less circular path, passing along the under side first in the root and along the upper side first in the stem. This current would be subject to leakage; the path is not properly insulated and shows a high resistance. Its effects would, therefore, be greater in the side through which it passed first, and by the loss of turgidity in the affected cells, one effect would be a slower rate of growth in the more affected side. Thus the under side of the root and the upper side of the stem, when stimulated by gravity, would grow more slowly. This in its turn would lead to downward curvature in the root and to upward curvature in the stem.

The direction of curvature is, according to this theory, governed by the direction of the electric current, which is governed by the sign of the electric charge on the moving particles, which is governed in its turn by the relative acidity or relative alkalinity of the protoplasm. The relative acidity or alkalinity is in its turn governed largely by the percentage of carbon dioxide in the cell, a quantity which depends upon both the breathing of the cell and upon the amount of sugar-building or photosynthesis which is going on. The latter process uses up carbon dioxide, while respiration increases the amount present.

For the details of the theory and experiments I refer you to the published account of my previous lectures, but in order to refresh your memories I now show a few lantern slides (some of which are given in the plates illustrating the above-mentioned account) of roots which have turned up at the tips in dilute ammonia vapour; of stems which have turned down in acetic acid vapour and in excess of carbon dioxide, and also as the result of being coated with vaseline and kept in the dark in order to retain the carbon dioxide of respiration.

The Critical Point for Reversal.

Having proved that the reversed curvature in excess of carbon dioxide is really a geotropic phenomenon, by means of rotation on a klinostat, Miss M. J. Lynn, M.Sc., investigated carefully the action of varying percentages of carbon dioxide on the geotropic curvature, and found that with 10.3% or more the stem of seedling sunflowers always turned down; while with 7.2% or less they always turned up. In the table given below from *The New Phytologist*, Vol. XX., p. 119, it will be seen that with 9% six turned up and two down (Expts. 20-21). The seedlings used in No. 20 had been grown in bright light, with photosynthesis active and all available carbon dioxide being used up; when these seedlings are taken as not quite normal compared with the others grown in dull light, the critical percentage of carbon dioxide for normal seedlings falls to 9%. Similarly the two seedlings in Expt. 27 were grown in very dull light and may be taken as abnormal; then all other seedlings in 7.76% or less turn up in the normal way. This variation in the critical percentage of carbon dioxide, for reversal of the direction of geotropic response in the stem of seedling sunflowers which have been grown in various intensities of light, indicates that photosynthesis plays an active part in determining the reaction or hydrion concentration of the stem within certain limits.[1] This will become more apparent when we discuss heliotropism and its reversal.

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1 Miss Lynn's work has been published in some detail in *The New Phytologist*, Vol. XX., 1921.

TABLE I.

Date of experiment	Number of seedlings	Number of seedlings showing curvature	Volume of jar in c.c.	Per cent. CO_2 (by analysis)	Temperature °C
1. 1st Dec. ...	5	5 down	4000	33	14
2. 11th Feb. ..	7	7 ,,	7000	32	12
3. 11th Feb. ...	9	9 ,,	7000	29.7	12
4. 17th Jan. ...	3	3 ,,	4000	26	13
5. 19th Nov. ...	3	3 ,,	4000	25	14
6. 11th Feb. ..	4	4 ,,	7000	22	12
7. 25th Nov. ..	3	3 ,,	4000	20.9	14
8. 30th Nov. ..	2	2 ,,	9000	20	13
9. 19th Jan. ...	5	5 ,,	4000	19.6	13
10. 1st March ..	5	5 ,,	7000	18	12
11. 27th Jan. ...	2	2 ,,	9000	16.8	14
12. 22nd Nov. ...	7	6 ,,	4000	16	14
13. 21st Jan. ...	5	5 ,,	4000	14.5	13
14. 7th Feb. ...	3	3 ,,	7000	14	11
15. 7th Feb. ...	10	9 ,,	7000	13.3	11
16. 20th Jan. ...	4	4 ,,	5500	12.6	14
17. 21st Feb. ...	2	2 ,,	7000	10.5	13
18. 18th April ...	7	7 ,,	7000	10.4	14
19. 1st Feb. ...	2	2 ,,	4000	10.3	13
20. 14th March	6	6 up	7000	9	14
21. 1st Feb. ...	2	2 down	4000	9	14
22. 14th March	7	7 up	7000	8.2	14
23. 23rd Feb. ...	4	4 down	7000	8	14
24. 10th March	7	1 down 6 up	7000	7.9	13
25. 11th March	7	7 up	6250	7.76	15.5
26. 16th March	9	9 ,,	7000	7.6	14
27. 21st Feb. ...	2	2 down	7000	7.4	14
28. 17th Feb. ...	9	9 up	7000	7.2	14
29. 15th March	7	7 ,,	7000	7.1	14
30. 25th Feb. ..	5	5 ,,	6250	7	14
31. 25th Feb. ...	8	8 ,,	9000	6	14
32. 14th Feb. ...	2	2 ,,	7000	5.2	13
33. 15th March	9	9 ,,	7000	5.2	14

Extension of Reversal of Geotropic Response of Stems to Representative Species.

Although Miss Lynn had obtained reversal in the seedlings of *Clarkia elegans*, and of *Antirrhinum* in addition to those of the sunflower, it was not certain that this reversal would occur with all species and with mature stems. Therefore, Miss M. W. Rea, M.Sc., undertook an investigation of other species. She extended the experiments, using the same method as employed by Miss Lynn without, however, analysing the atmosphere in the bell-jars to check the percentage of carbon dioxide as the fact of reversal was the point under investigation. The time taken for downward curvature to appear was noted and the angle made with the horizontal was measured with a protractor. The material included seedling stems, the upper parts of mature vegetative shoots and flowering shoots. Each specimen was placed horizontally in excess of carbon dioxide and left in the dark. A total of 190 species were investigated; of these 179 showed reversal of the normal upward response to a greater or lesser degree; while 11 failed to show curvature at all. In all these eleven species control specimens laid horizontally in fresh air showed no curvature. These results are still under consideration, but in order to give you some idea of the scope of the work I give a list of the families represented and of some of the more definite results:—

Ranunculaceae—14 species belonging to 8 genera, including

Anemone nemorosa,	curved	70°	in	4 hours	in 30%	carbon dioxide,
Aquilegia vulgaris,	,,	45°	,,	4 ,,	,, 45%	,,
Ranunculus auricomis,	,,	45°	,,	4 ,,	,, 30%	,,
,, *repens*	,,	45°	,,	3 ,,	,, 30%	,,
Trollius europaeus,	,,	75°	,,	4 ,,	,, 50%	,,

Papaveraceae—2 species belonging to 2 genera.

Fumariaceae—*Dicentra* sp.

Cruciferae—15 species belonging to 15 genera, including

Arabis sp.,	curved 30°	in 1 day	in 30%
Cheiranthus Cheiri,	,, 45°	,, 1 ,,	,, 30%
Cochlearia officinalis,	,, 30°	,, 1 ,,	,, 45%
Iberis amara,	,, 45°	,, 4 hours	,, 45%
Lepidium sativum,	,, 45°	,, 3 ,,	,, 45%
Matthiola incana,	,, 15°	,, 1 day	,, 30%

Cistaceae—*Helianthemum* sp.

Violaceae—*Viola tricolor*.

Polygalaceae—*Polygala vulgaris*, curved 10° in 1 day in 50%

Caryophyllaceae—9 species belonging to 6 genera, including

Cerastium vulgatum,	curved 30°	in 1 day	in 45%
Lychnis dioica,	,, 45°	,, 1½ hours	in 50%
Stellaria media,	,, 35°	,, 4 ,,	,, 50%

Hypericaceae—*Hypericum*, 4 spp.

Geraniaceae—*Pelargonium* sp. (hairy var.)

curved 45° in 1 day in 30%

do. (smooth) ,, 30° ,, 4 hours,,30%

Tropaeolaceae—*Tropaeolum* sp.

Limnanthaceae—*Limnanthes* sp.

Leguminosae—8 species belonging to 6 genera, including

Lotus corniculatus,	curved 45°	in 1 day	in 50%
Lupinus sp.,	,, 30°	,, 3 days	,, 45%
Trifolium dubium,	,, 30°	,, 4 hours	,, 60%
,, *pratense*,	,, 35°	,, 4 ,,	,, 60%

Rosaceae—8 species belonging to 6 genera, including

Alchemilla vulgaris,	curved 45°	in 4 hours	in 60%
Geum sp ,	,, 75°	,, 1 day	,, 45%
Pyrus aucuparia,	,, 90°	,, 4 hours	,, 45%

Saxifragaceae—4 species belonging to 2 genera, including

Heuchera parviflora, curved 90° in 4 hours in 50%

Ribesiaceae—*Ribes*, 5 spp.

Crassulaceae—*Sedum Telephium*.

Begoniaceae—*Begonia* sp.

Oenotheraceae—3 species belonging to 2 genera, including
Epilobium montanum, curved 45° in 1 day in 45%

Umbelliferae—9 species belonging to 9 genera, including
Oenanthe crocata, curved 45° in 3 hours in 45%
Myrrhis odorata, ,, 35° ,, 1 day ,, 30%

Caprifoliaceae—*Sambucus nigra.*

Rubiaceae—2 species belonging to 2 genera.

Valerianaceae; *Valerianella olitoria.*

Compositae—18 species belonging to 15 genera, including

Bellis perennis,	curved	75°	in 1	day	in 30%
Chrysanthemum Parthenium,	,,	90°	,, 4	hours	,, 45%
Hieracium Pilosella,	,,	75°	,, 1	day	,, 33%
Hypochaeris radicata	,,	75°	,, 1	,,	,, 33%
Senecio vulgaris	,,	45°	,, 1	,,	,, 30%
Tussilago Farfara,	,,	75°	,, 1	,,	,, 30%

Campanulaceae—*Campanula*, 2 spp.

Plumbaginaceae—*Statice*, 2 spp.

Primulaceae—2 species belonging to 2 genera, including
Primula vulgaris, curved 30° in 1 day in 30%

Oleaceae—*Ligustrum vulgare.*

Gentianaceae—*Gentiana acaulis* (flowering axis).

Apocynaceae—*Vinca minor.*

Asclepiadaceae—*Asclepias curassivica.*

Polemoniaceae—2 species belonging to 2 genera, including
Polemonium caeruleum, curved 90° in 1 day in 50%

Boraginaceae—5 species belonging to 4 genera, including
Symphytum officinale, curved 90° in 4 hours in 50%
Pulmonaria officinalis, ,, 50° ,, 4 ,, ,, 30%

Solanaceae—3 species belonging to 2 genera, including
Solanum dulcamara, curved 40° in 3 hours in 45%

Scrophulariaceae—7 species belonging to 4 genera.

Labiatae—8 species belonging to 7 genera, including
Salvia officinalis, curved 80° in 4 hours in 45%
Ajuga reptans, ,, 35° ,, 4 ,, ,, 60%

Plantaginaceae—*Plantago*, 4 spp.

Chenopodiaceae—*Atriplex*, 2 spp.

Polygonaceae—*Rumex*, 3 spp.
Urticaceae—*Urtica* (flowering axis) curved 30° in 2 hours in 60%
Euphorbiaceae—*Euphorbia lucida.*
Araceae—*Arum maculatum.*
Gramineae—*Zea Mays.*
Liliaceae—8 species belonging to 7 genera, including

Hyacinthus sp.	curved	40°	in 4	hours	in 30%
Scilla verna,	,,	45°	,, 1	day	,, 33%
Tulipa Gesneriana,	,,	45°	,, 4	hours	,, 30%

Amaryllidaceae—*Narcissus Pseudo-narcissus*, curved 30° in 1 day in 30%
Orchidaceae—3 species belonging to 2 genera, as follows

Listera ovata,	curved	90°	in 3	hours	in 45%
Orchis maculata,	,,	90°	,, 3	,,	,, 45%
Orchis mascula,	,,	45°	,, 1	day	,, 45%

The list is sufficient to show that we can now generalise with some safety, and say that any plant which shows negative geotropic curvature under normal conditions will probably show reversal or positive geotropic curvature in excess of carbon dioxide. It is, perhaps, needless to state that the curved stems in all cases were turgid, and that the downward curvature was a positive active movement, not a drooping passive movement of a flaccid structure. Indeed, one of the most surprising features of these experiments was the freshness of stems which had been for days in an atmosphere which it has been usual to describe as toxic; many of the species remained fresh much longer in excess of carbon dioxide than in ordinary air.

Miscellaneous Investigations.

A study of the responses of *Phaseolus*, the French bean, has been made by Miss F. M. Adams, M.Sc. The main stem was found to show the usual reversal of the direction of geotropic response in 30% carbon dioxide. This plant, however, also shows what are called sleep movements. Each leaf-stalk and each stalk to the leaflets has a pulvinus or cushion of special tissue at its base, and movement takes place at these points. The main stalk of each leaf and the leaflets all droop in dark, rising again in light, with a daily periodicity which continues for a day or two even when the plant is kept continuously in the dark. These normal movements are controlled partly by gravity (which determines the *direction* of the movement) and partly by light (variations in which initiate the actual drooping or rising). It was found that the addition of 20% carbon dioxide caused the leaves to assume the night or dark position, but further experiments are required to show whether this is an anæsthetic effect or an effect of change in hydrion concentration. These are being carried on.

It is "common knowledge" that carbon dioxide in excess retards the growth of stems, and further experiments are being conducted on the degree of retardation in varying percentages of that gas by Miss Rea and the writer with simple auxanometers magnifying 24 times. These are still unfinished, but the results to date show that with 5% carbon dioxide there is little or no retardation in the dark, while in the light there is a distinct acceleration of the rate of growth in stems. With 30% carbon dioxide there is a retardation after the first few hours even in the presence of light, and this becomes more distinct when the plants are kept in the dark.[1]

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1 Since this lecture was delivered the acceleration of the rate of growth in the sunflower stem, which was noted in light with 5 per cent. carbon dioxide, has been conclusively proved to occur in darkness during the first hour of exposure to the gas in any percentage of carbon dioxide from 10 per cent. to 100 per cent. The subsequent retardation begins during the second or third hour and has been confirmed during the fourth hour for all percentages above ten. The effects of percentages below ten have still to be investigated. The initial acceleration by carbon dioxide of stem growth in darkness lasts for at least thirty minutes. This phenomenon may be correlated with the change in geotropic response noted by Miss M. J. Lynn (p. 26), and may be regarded as due to increased acidity in an already acid, positively geotropic tissue.

These experiments on stem growth are to be correlated with work by Miss I. Finnegan on the rate of growth of roots in carbon dioxide. The apparatus used is a modification (whereby a higher degree of accuracy can be obtained) of a simple root auxanometer which was devised and described by Professor W. Neilson Jones.[2] The results obtained, although they vary considerably, tend to support the idea that the rate of root growth is accelerated by excess of carbon dioxide. All these investigations are still in progress, and the results are mentioned to-night because some of you may be interested in what we are, at the moment, working upon.

Reversal of Heliotropic Response in Stems.

In the report of the previous lectures (*op. cit.*, p. 98) under the heading of "Another Cause of Erectness in Plants" certain preliminary experiments by Miss I. Finnegan, M.Sc., on the reversal of normal heliotropic curvature were mentioned. This investigation has been carried to a point where we can now be positive about the fact of reversal, but there remains a number of points to be investigated before the theory of the direction of heliotropism being governed by the percentage of carbon dioxide in the stem can be considered proved in detail. Several methods were adopted in the attempt to get conclusive results. The chief points to notice in the tabular summary below are—1. "slit light constant" means that the sunflower seedlings were exposed in a bell-jar to continuous illumination; 2. the seedlings were placed erect at first, but, since it has been shown that seedlings of sunflower turn downwards in more than 10% carbon dioxide, they were afterwards inverted to avoid the possible error due to reversed geotropic response. In the last series of experiments they were placed horizontal and kept for three or fours hours in the dark so that they might attain geotropic equilibrium before being stimulated by light.

2. Annals of Botany, XXXIV., p. 555, October, 1920.

TABLE II.

Methods	Per cent. of Carbon Dioxide	Total No. of Seedlings	Results		
			Curved away	Nil	Curved towards
A. Seedlings erect. Per cent. CO_2 not analysed Slit light constant	16 to 45	12	9	3	0
B. Seedlings erect. Per cent. CO_2 analysed Slit light constant	4.6 to 5.9 7.5 to 9.1 10.4 to 42.1	11 30 89	0 10 32	0 3 24	11 17 33
C. Seedlings erect. Per cent. CO_2 analysed. Slit light for 1 hour, then dark	13.1 to 26.7 27.4 to 33.7	21 24	0 19	4 5	17 0
D. Seedlings inverted Per cent. CO_2 analysed. Slit light for 1 hour, then dark	19.6 to 28.3 29.4 to 35.1	11 13	0 11	4 2	7 0
E. Seedlings inverted per cent. CO_2 analysed. 3-4 hours dark, then 2 hours light, then dark	21.9 25.4	5 3	0 3	0 0	5 0
F. Seedlings horizontal. Per cent. CO_2 analysed. 3-4 hours dark, then slit light constant	5.2 to 16.9 18.2 to 31-1	54 38	8 17	6 6	40 15

In the first series, A, every curvature was reversed, but the seedlings, being erect in more than 10% carbon dioxide, would have curved in any case. The results indicate, but do not prove, that the direction of response to light has been reversed, otherwise some of the seedlings would have curved downwards but *towards* the light.

In the second series, B., these conclusions are supported by the increasing proportion of the seedlings turning away from the light with increasing concentration of carbon dioxide. In both these groups, however, there seems little doubt that, during the *continuous* exposure to light, photosynthesis used up the internal carbon dioxide and interfered with the heliotropic response.

In the third series, C., the exposure to light being limited to one hour, the disturbing action of photosynthesis is more or less eliminated, with the result that all curvatures in more than 27% of carbon dioxide are reversed.

In the fourth series, D., the disturbing effect, if any, of positive geotropism in the stem is eliminated by the inversion of the seedlings. Photosynthesis is also eliminated as far as possible. The result is the reversal of all curvatures in more than 29% of carbon dioxide.

In the fifth series, E., the seedlings were given three or four hours in the dark in which to settle down in the excess of carbon dioxide, with the result that the percentage of carbon dioxide necessary for reversal is apparently reduced from 27—29% to something below 25.4%.

In the sixth series, F., the results again show the disturbing effect of photosynthesis with continuous illumination.

Further experiments are being conducted which indicate that the intensity of the illumination has a distinct effect on the percentage of carbon dioxide required for reversal. Most of the experiments in the table were carried out during the dull winter days in a rather dull window; this may account for the close approximation (25 to 29% of carbon dioxide) of the results in the series C., D. and E.

The theory upon which these experiments are based is given briefly in *The New Phytologist*, Vol. XIX., p. 275, 1920.

THE STIMULATION OF ROOT PRODUCTION BY ACIDIC MEDIA.

I have Sir Isaac Bayley Balfour's permission to tell you of the work on this subject, which was begun at the Royal Botanic Garden, Edinburgh, by himself and Mr. Lawrence Stewart. The idea occurred to Professor Balfour on perusing that section of my textbook which deals with acid root and alkaline shoot, and with the kind permission of the Edinburgh workers Miss Lynn and I have extended the investigation in the new greenhouses of Queen's University.

The idea underlying the work can be described very briefly. If the root is an acid structure, root-production in the striking of cuttings should be stimulated by acidic media. Oaks are not known to have been propagated by cuttings until recently, when at Edinburgh oak cuttings were induced to strike root by the rather special methods in use there. The percentage of successes even after ten months was very low but, when the cuttings were watered with the acidic supernatant fluid obtained by soaking peat in water, the percentage of successes became very high and the cuttings struck root in about two months. This work is being continued by Mr. Lawrence Stewart.

At Queen's we have some 1,500 cuttings mostly arranged in ten groups, each group being treated differently. These have as yet given no definite results, but they are all of species which are known to be very difficult to strike. We have also 50 rose cuttings, in groups of ten; watered periodically with—1. cold water; 2. hot water, about 60°; 3. cold dilute acetic acid, 1 in 1,000; 4. cold dilute acetic acid, 1 in 10,000; 5. hot dilute acetic acid, 1 in 10,000. These cuttings are all inserted loosely in coconut fibre which retains the moisture well and is very slightly acid in itself. Within three weeks two cuttings struck root, and these were in the lot which were being watered with hot acid.

Within six weeks eight cuttings out of the ten in hot acid had struck root, while the other sets showed not more than from one to four cuttings with roots.

Another test was made with cuttings of *Chrysanthemum* sp., of which eleven were treated with hot water alone, and nine with hot dilute acetic acid. Within one week seven out of the nine in hot acid had struck and the other two struck during the following week. Of the eleven in hot water only two struck during the first week and another one during the second week, while the rest failed altogether. It seems clear, therefore, that root development in cuttings is stimulated by acidity of the medium in which they are set, especially if the temperature be raised temporarily.[1]

The Stimulation of Root Production by Carbon Dioxide.

The work on cuttings described above is purely a search for a method by which propagation of plants by cuttings on a commercial scale may be rendered more rapid and more

1. Since this lecture was delivered certain other results have been obtained. Using the same four boxes as before and watering periodically with the different fluids we have obtained the following:—

Cuttings put on		Callused or Rooted			
Plant	Number	Cold Water	Hot Water	0.1% Acetic Acid	0.01% Acetic Acid
Privet ...	10	2	6 (less healthy)	3	6 (very healthy)
Rhododendron ...	10	0	2	2	5
Veronica ...	20	3	0	0	7
Totals ...	40		8	5	18

A once sceptical chemist has also reported the following—"Two dozen 'Japonica' cuttings were put in earth in the open on 21st March. One dozen were left to be watered by rain; the other dozen were watered twice with 3-4 parts of ordinary vinegar in 200 parts of warm water. On the 2nd of May the first dozen were all dead, while 9 of the second dozen had struck root and seemed quite healthy.

Many other cases of successful 'striking' of cuttings from shrubby plants in the open, after watering with acid water (three teaspoonfuls of ordinary vinegar to the gallon of tepid water), have also been reported. The writer will be glad of notes on any amateur work done along these lines, especially with shrubs which are difficult to strike."

certain; but, from the standpoint of the theory of differentiation of root and shoot in their reaction or hydrion concentration and the control over that factor exercised by carbon dioxide, certain other experiments were indicated as being of purely scientific value.

Cuttings of the oak and of the spotted laurel (*Aucuba japonica*) were inserted through holes in sheet cork fitted into the tops of two flat museum jars. The cork fitted closely, all holes being sealed with plasticine, and each jar was fitted with two tubes by which water and gases could be passed in. Water was run in until it just reached the tips of the cuttings, and it was kept at that level throughout the experiment. Then air was drawn through the space between cork and water in one jar, while pure carbon dioxide was drawn through in the other jar. This "aeration" was continued for about fifteen minutes, and repeated at weekly intervals for one month. The oak cuttings have still failed to show any signs of striking, but after one month five of the six *Aucuba* cuttings treated with carbon dioxide showed good callus, and two of these had sent out roots; of the six *Aucuba* cuttings which were treated with ordinary air one had sent out two roots with little callus, and none of the other five showed any signs of callus or roots. (Figs. 1 and 2, Plate I.)

Another experiment was carried out with *Bryophyllum calycinum*, the American life-plant. A single leaf was taken and cut carefully in two up the centre of the midrib. One half was suspended with its tip in water and carbon dioxide was drawn into the bottle through two tubes in the cork as before. The other half was suspended in the same way and treated with ordinary air. In air nothing happened during the first month, but in carbon dioxide two sets of long roots were developed from two of the lower notches of the leaf margin. Two weeks later two small, but healthy, deep green shoots with corresponding short roots were developed on the half leaf in air; while by that time more long roots had grown from the same two notches of the half leaf in carbon dioxide, and one corresponding shoot had grown out from one of the notches. This shoot was of the shade type, with pale green colour, large thin leaves and longer internodes than in the control. Further growth only emphasised the difference between these two sets. No shoot has yet arisen from the first group of roots to develop in carbon dioxide, while the stem of the other plantlet shows quite long internodes, and the shoot has a general appearance of etiolation. The roots of the plantlets in air remain short, and the stems also are still short with numerous dark green leaves and short internodes. (Figs. 3 and 4, Plate I.)

These two sets of experiments on the influence of carbon dioxide on the development and growth of roots are, of course, not conclusive, but they tend to support the general position, and further work on these lines is in progress.

BIBLIOGRAPHICAL.

The Hydrion Differentiation Theory of Geotropism was first published in April, 1920, and in the following month two papers appeared which have important bearings upon the theory.

The first is " Studies on the Reaction of Plant Juices," by A. R. C. Haas, [1] of the University of Wisconsin, who determined the actual acidity of parts of various plants. Expressed as PH numbers (which increase with decrease in acidity), his results with medium red clover are:—Leaves 6.19-6.02, tops 6.12-5.94, roots 5-92-5.82. Then he heads a paragraph with " Is there a gradient of reaction in plants?" and gives the following data as " the actual acidity determinations of the juice taken from different portions of the same plant "—

" Reaction "	Part of Plant.
8.00	Upper 3 inches of the tops, stem, leaves and buds.
7.04	Leaves and petioles of remainder of tops (no stems).
6.68	Stems to about 2 inches above the soil (no leaves).
6.46	2 inches of lower part of stem and 2 inches of upper part of root.
5.82	Root: 6-inch portion below the upper 2 inches of root.

The second is a paper in the *Journal of General Physiology* for May, 1920, by Jacques Loeb on " The reversal of the sign of the charge on protein membranes," in which it is demonstrated experimentally that there is a change in the sign of the electric charge on protein membranes with a change in the hydrion concentration of the surrounding medium beyond the iso-electric point of the protein used. Later papers in the same journal by the same author extend this proof to protein particles.

1. Soil Science, Volume IX, No. 5—May, 1920.

Two points of importance in the theory, namely the acidic root-tip and the alkaline stem-tip, and the change in the sign of the charge on the protein, received experimental support within a month of publication.

Criticism has, of course, abounded, but has reached print only in a few cases. In fact, I at one time considered the issue of " A Guide to Critics," for no one seems to realise more than I do just how many points in connection with the theory still call for experimental evidence. As a theory it has already justified its publication, firstly on account of the experimental work to which it has been a guide, and secondly on account of the attention which has since been given to hydrion concentration in plants.

The first criticism published was by Professor V. H. Blackman, who suggested that the hypothecated " creaming " could not be effective on account of the small size of the " ultramicroscopic " particles. This was answered fully in the following number of the same journal, the *New Phytologist* (June, 1921), where it was pointed out that the size of the particles could be taken as much larger than was supposed in the criticism, and that the creaming of such particles might, theoretically, be effective. My critic replied to this with an *argumentum ad populum* which has no scientific value, and need not be discussed.

The second criticism was by Professor J. H. Priestly in *Science Progress* for December, 1921. He intervened in the controversy to point out that the creaming was not absolutely necessary, since a delicate membrane such as occurs in the cell might have a different electric charge in different media, and might be sensitive to the change in hydrostatic pressure produced by turning the plant. Apart from the great similarity in the height and width of the cells in question, the membrane would require to be sensitive to the difference between 1 in about 600,000 and 1½ in 600,000 if hydrostatic pressure were to be effective. But this suggestion may be helpful in another way, since it is possible that the loose starch grains, known as statoliths, falling upon the delicate charged membranes may produce electric currents of stimulation which would pass in different directions according to the sign of the charge on the membrane. Work on these lines is proceeding.

A third criticism has appeared (*New Phytologist*, December, 1921) by R. Snow which, although rather confused, is easy on the whole to answer, with a theoretical answer to a theoretical criticism. The value of the theory, of course, lies in its practical experimental results. Snow first supposes a single cell to be isolated, and then, comparing this with a Voltaic cell set up with terminals unconnected, says there can be no current. The cells are, however, never isolated in nature, and the surrounding tissue is usually a conducting path for any current present. He next questions the statement that Bose found in stems and roots currents of the required kind, and suggests that if any current does occur it will flow in the opposite direction "to that required by Professor Small." This part of his criticism seems to be based upon an assumption that the original theorist was unaware of the direction of flow of the current in an ordinary Voltaic cell. However, in the brief quotation of the results reported by Bose due allowance was made for the direction of the flow being from negative pole to positive pole *in the cell* or from electro-positive element to electro-negative element in the Voltaic cell, as well as for other still undiscussed points, such as the relative resistance of tissue and wires in the experimental arrangements used by Bose in his investigations of the potential differences in plants.

On one point he frankly asks for information. It has been supposed that the current will produce a greater effect in that side of the organ along which it flows first "on account of the resistance in the circuit." The resistance as measured is as much as 10,000 ohms for a length of one millimetre. With such a high resistance there are various theoretical possibilities, any one of which may prove to be the acting cause, or the various factors may act together, their effects being increased by subsidiary phenomena; to mention only one or two possibilities—there may be an asymmetric current density on account of the presence of more free liquid outside the cells, or for other reasons, such as the leakage of the current through the endodermis into the pith or into the conducting strands; there may be a capacity effect similar to that shown by submarine cables, bringing a time factor into the flow of the current. When there are so many alternative explanations, direct investigation is preferable to a balancing of theoretical possibilities.

The last part of his criticism I have entirely failed to understand. One or two extracts may make the reason for this apparent. "The chief source of difficulties is surely the practice of speaking of 'currents' in tissues. . . . . in a state of nature, though it is evident that such must occur, by local short-circuiting through cell-walls *or other paths.*" [1] "Such currents must, in fact, occur if the two points at different potential are connected also by tracts of conducting tissue . . . the resulting currents will be circular, flowing in one direction along the one path and in the other direction along the other" (cp. the diagrams of the supposed path of the current in previous accounts of the theory). There may be something in this beyond a re-affirmation of the original standpoint of the theory, but I really fail to see it.

Summary of the Present Position of the Hydrion Differentiation Theory.

1. The essential difference between shoot and root in their responses to gravity and to light is proved to be one of relative acidity and alkalinity. This is demonstrated by the experimental facts—

(a) the curving of roots upwards in an alkaline atmosphere,

1. The Italics are mine.

(b) the curving of shoots downwards in an acidic atmosphere,

(c) the precision of the control by carbon dioxide of upward or downward curvature in the sunflower stem,

(d) the extension of this phenomenon of reversal of normal gravity-curvature to the stems of a large number of other species,

(e) the reversal in carbon dioxide, with recovery in fresh air, of heliotropic response.

2. It has been proved that there is a difference in electrical conductivity between the upper and under sides of a root which has been stimulated by gravity.

3. Since even the experimental observations of the chief plant electro-physiologists, Bose and Waller, are not universally accepted, the hypothecated currents have still to be demonstrated, together with their supposed effects.

4. It has also still to be demonstrated either that particles which are electrically charged do cream in the sensitive regions or that the impact of the statoliths on differently charged membranes gives currents opposite in direction. Indeed, beyond the points given in paragraphs 1 and 2, the whole of the hypothecated mechanism of gravity perception and response has still to be investigated experimentally.

5. Geotropism has been described by one critic as " one of the most obscure of physiological phenomena." One cannot, therefore, expect to solve to the point of experimental demonstration all the problems connected therewith in one set of experiments; but it may be taken as a hopeful sign that the first points for which we have obtained experimental proof have led almost immediately to a practical application which promises to be of considerable value.

7th March, 1922.

HENRY RIDDELL, ESQ., M.E., President of the Society, in the Chair.

"THE OPTOPHONE: AN INSTRUMENT FOR READING BY EAR."

By E. E. FOURNIER D'ALBE, D.Sc. (Lond. & Birm.). A.R.C.Sc., M.R.I.A., F.Inst.P. Honorary Member of the Society.

The problems presented by blindness can be approached along several different lines. The physician will endeavour to prevent the diseases giving rise to blindness. The opthalmic surgeon will cure blindness by operation in cases which do not transcend his skill. The philanthropist will mitigate the evils of blindness by means of special educational facilities and by the provision of remunerative employment.

To-day I wish to direct your attention to certain more radical methods of approach, which are based upon the fundamental principles underlying all sense perception.

Physiologists inform us that the retina of the eye consists of skin containing nerve endings specially adapted to the perception of light. The general sensibility of the skin is modified so as to react to ether waves instead of bodily contacts or heat or cold. The sense organs are, it appears, mere modifications of the ordinary skin, and, in their original forms, they are mere depressions in the surface of the skin, lined with a finer skin sensitive to ether waves (eye), air waves (ear), or to the chemical properties of gases (nose), and liquids (mouth) respectively.

Bearing this in mind, we may conclude that the most direct way of replacing one of these senses, if lost, is to translate its action into terms of some other sense, preferably the sense which is most closely allied to the lost one. Thus, if light could be made audible, and if sound could be made visible, we should be in a position to replace the eye by the ear and the hearing by sight, and the problems both of blindness and deafness would be practically solved.

We have thus reduced the problem to a problem of physics. It is the physicist whose business it is to study the properties of sound and light, and it is to him we must look for methods of translating one into the other. It is, therefore, very appropriate that I should describe to you one solution of the problem of blindness in this building devoted to the study of physics, the most fundamental of the exact sciences.

The difficulty which confronts us at the outset is the enormous disproportion between the rapidities of sound waves and light waves. If an ordinary light impulse could be slowed down so as to last a whole second, an ordinary sound wave, slowed down in proportion, would last 200 million years!

It is, therefore, quite futile to hope to make the ear directly sensitive to light waves. Not that the ear is insufficiently sensitive—it is actually as sensitive as the eye, the minimum energy required to stimulate either sense organ being approximately the same. But in order to translate light into sound we must find some intermediate link.

Such an intermediate link is found in electricity. Minute electric currents can be made audible in a telephone. So our problem reduces itself to one of producing electrical effects by means of light.

There are various ways of doing this. The thermo-couple or thermo-electric cell converts radiant heat into electric current. The "photo-electric" cell," consisting of a "retina" of colloidal potassium or rubidium mounted in a vacuum and connected with a battery gives a minute current when illuminated, a current which varies in close proportion with the illumination.

But there is one substance which transcends all these a millionfold in efficiency, and that is the light-sensitive variety of the element selenium, discovered by Berzelines a hundred years ago. The discovery of its light-sensitive properties was not made until 1873, and then it was discovered by accident in Valentia Island, in the County of Kerry, in connection with some work on transatlantic telegraphy.

Selenium, even in the allotropic form which conducts electricity, has a high resistance. The selenium tablet (sometimes called a " selenium cell ") must therefore be designed so that the conductivity is as high as possible. This is done by having numerous conducting elements bridged over by short bridges of selenium. The best method is to coat a plate of unglazed porcelain with graphite and inscribe upon it with a diamond a fine zig-zag line cut through the graphite into the porcelain. A conductivity of some 5 " micro-mhos " per centimetre of line may thus be obtained, giving, with 100 volts, a current of half a milli-ampere. This current may be doubled or trebled by suitable illumination. As a square inch plate is sufficient to contain a zig-zag line of a total length of 20 centimetres, we can thus obtain a current of some 10 milliamperes, or a " useful " current due to light of the same amount or more.

As modern instruments go, this is the sort of current with which many things can be done. A small current may be amplified a thousand times by means of relays, so that in the end we may produce quite formidable effects by means of a ray of light alone.

Thus, we may use a beam of light to produce an electric current through selenium. This current may work a relay which switches on a stronger current, and that current may be used to, let us say, spring a mine. Such an experiment I can show you now. I have here a small model of a search-light which I can turn in any direction I please. I shall throw the beam across the Lecture Theatre on to a selenium tablet in circuit with a relay. You can see the beam travelling across the room, and as soon as it impinges upon the selenium there is the loud report which tells us that the "mine" has been exploded. (Demonstration.) There would be no doubt in the blind man's mind that the light had been shining on the selenium!

The light can also be made to ring a bell (demonstration) and to act in numerous different ways. But searchlights are not the kind of thing that a blind person would ordinarily wish to discover. Most visual appearances are of much smaller intensity, and they require more delicate apparatus to bring them home to the ear.

A method of making ordinary lamplight and daylight "audible" is illustrated by the diagram (Fig. 1). It represents what electricians call a "Wheatstone Bridge" arrangement of four conductors, two of which (Se.) are of selenium, while the remaining two are of graphite (C.). There is also a variable resistance shown as a zig-zag line, connected by a movable arm to the battery in the centre. The outer covers are joined through a telephone receiver (Te.) and a clock-work interruptor.

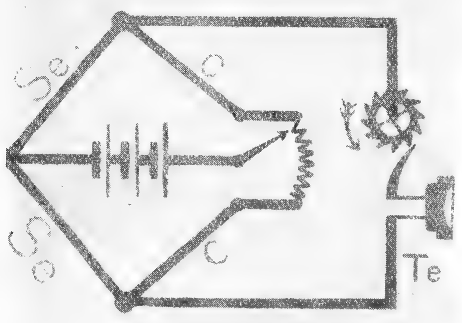


FIG. 1.

The instrument acts as follows:—In the dark, the resistances of the two selenium tablets (Se.) are equal, and so are the two carbon resistances (C.). As a consequence, there is no current in the telephone circuit, and the interruptor, maintained by clockwork, produces no sound in the telephone. If now one of the Se. tablets is illuminated the balance is upset, and a current traverses the telephone and becomes audible by virtue of the interruptions (a steady current is inaudible in a telephone).

The various parts of the instrument are packed in a case resembling a camera (Fig. 2), only the telephone being outside the case, as it has to be worn on the head.

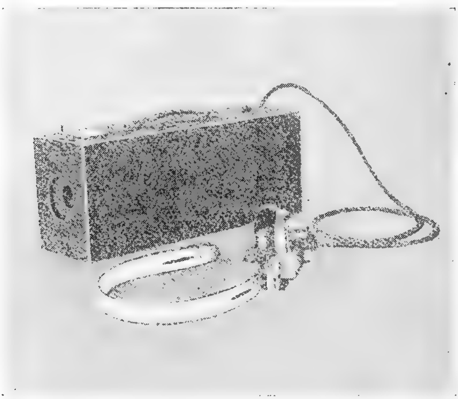


FIG. 2.

I devised the above instrument in 1912 while at the University of Birmingham. A gifted blind man in Birmingham used it for finding lamps and windows, and was even able to count a number of nurses in a row by listening to the sound produced by their white aprons!

Certain heads of institutions for the blind represented to me, however, that the instrument was of little practical utility to the blind, and so I was obliged to make further researches with a view towards finding something undeniably useful. The result, after a further two years' work, was the Type-reading Optophone, which, at all events, enables totally blind persons to read ordinary printed books and newspapers.

The essential parts of this instrument are a revolving perforated disc of the type known as a Siren disc (Fig. 3) and a perforated selenium tablet. The disc revolves some 30 times per second in front of a linear source of light extending from the centre of the disc to its rim. The line of light is thus broken up into five dots of intermittent flashes, with a frequency of from 600 to 1,200 flashes per second. These frequencies are of the order of musical sounds, and the five dots represent the scale of Soh, Doh, Re, Mi, Soh. All these notes, sounding together, form a discord, but if the Re is omitted a common chord is formed.

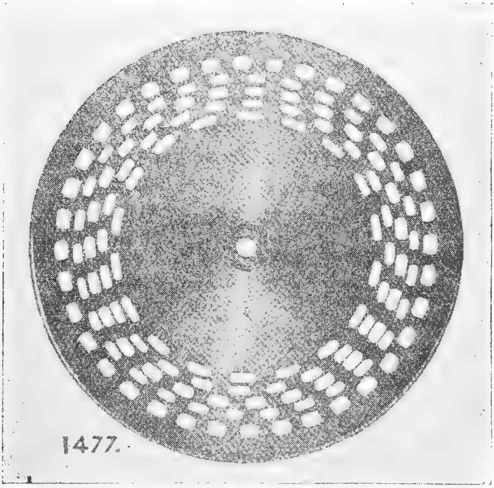


FIG. 3.

The line of " musical dots " having thus been obtained, the remainder of the construction is mainly devoted to throw the line of dots upon the type to be read, and to let the letters pick out various notes which will enable us to recognise them by their sounds.

A system of lenses is designed in such a manner that a small image of the line of dots or " scala "—just sufficient to fill up the letter *l*—is thrown upon the type to be read, This has to be done from below, as only thus can we hope to arrange bound volumes for reading. The illustration (Fig. 4) shows an upright column which contains the disc and the system of lenses. This column or " tracer " swings on the lower axis. The top of the tracer holds the perforated selenium tablet which moves through an arc of about 8 inches close to the type, but separated from it by a bent glass cover. Books and newspapers can be clamped on this cover. The movement along the line of print takes place under the action of a spring and is governed by an oil governor which can be adjusted so as to read the line in anything from 3 seconds to 3 minutes.

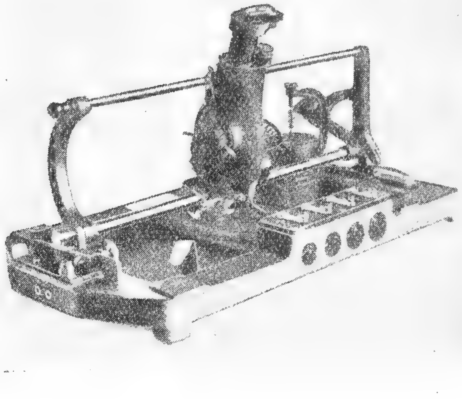


FIG. 4.

A friction clutch or a rack-and-pinion device are used for changing to the next line, and this change can be adjusted to any line interval used in printing.

A simple displacement of one of the lenses enables the reader to adjust the size of the "scala" to fit any ordinary type used in books or newspapers, and this adjustment can be made by ear alone.

The first public reading demonstration with the Optophone was given at the British Scientific Products Exhibition in August, 1918, by Miss Mary Jameson, of South Norwood, who is blind from birth. An unknown page was selected from a book by the Chairman (Sir Richard Gregory), and Miss Jameson read a line from that page without a mistake, including punctuation. The speed of reading at that time was about 2 words per minute, but Miss Jameson has steadily increased that speed by practice, until her present speed is over 40 words a minute with ordinary reading matter. Miss Jameson is also the heroine of a remarkable exploit in Paris—that of reading unknown French print—accents and all!

In 1920 the late Sir Arthur Pearson, Bart., and Captain Ian Fraser arranged for a test course of instruction in Optophone reading at the National Institute for the Blind in London. The pupils selected were Mr. Emblen and Miss Mabel Green. Of these, the latter made the best progress. She is totally blind, and holds the speed record for Braille reading. She is also an expert typist and shorthand writer. I think I cannot do better than quote from the report of the examiner (Mr. H. Stainsby), as published in *St. Dunstan's Magazine*. Mr. Stainsby reports as follows:—

"I have tested Miss Green's reading on the Optophone on seven different occasions, each test being of thirty minutes' duration and on 'unseen matter.'

(1) Extract from 'Heroes of the Darkness,' eighty-five words in thirty minutes, say three words per minute.

(2) Extract from leading article of *Daily Telegraph*, sixty words in thirty minutes—two words per minute.

(3) Extract from 'Optimism':—

Test (*a*) Eighty-nine words in thirty minutes, say three words per minute.

Test (*b*) Seventy-eight words in thirty minutes, say two-and-a-half words per minute.

Test (*c*) Sixty-four words in thirty minutes, say two words per minute.

(4) Extract from 'The World I Live in,' sixty-five words in thirty minutes, say two words per minute.

(5) Extract from 'Pier's Plowman Histories, Junior, Book II.,' 119 words in thirty minutes, say 4 words per minute.

"It will thus be seen that the average speed is under three words per minute. Although slow the reading was accurate, very few words being unread or miscalled. Short and easy words of frequent recurrence were read with comparative ease, the reader evidently taking the word as a whole without analyzing into letters. This is borne out by the last test, which was from a junior school book in everyday English. Long and uncommon words, particularly those containing little used letters as 'z,' caused much delay and consequently brought down the averages. Towards the close of a test the reading became slower, demonstrating the fact that until it becomes mechanical it will be tiring. This was obvious in the last test, when Miss Green read the first twenty-four words in four minutes, or six words per minute. This condition exists in a very marked degree in tactile reading, learners always being recommended to take their lessons in small 'doses.'

"Notwithstanding this, I am assured by Miss Green that she does not experience any tired feeling. Further, she assures me that the process of listening neither prevents her from grasping the full import of what she has read nor detracts from the enjoyment which she ordinarily gets out of reading.

"Miss Green manipulated the instrument quite unaided, and occupied less than two minutes in placing her book in it ready for reading.

"I am informed by Mr. Emblen, the other Optophone student, that my tests, while perfectly fair, do not do justice to Miss Green. This is doubtless due to the fact that examinations of all kinds rarely show the examinee in the best light.

"In preparing this report I have had two main issues in mind, all others being in my judgment quite subordinate to these two. The first is, can blind people read ordinary ink-print matter? The reply to this is emphatically yes. The second is, can they read at a speed which would make it worth their while to adopt the Optophone as a reading instrument? On this point I have already shown that speed is slow, but as a set-off against this it should be borne in mind, first, that no one has had adequate practice upon it, and secondly, that the right type of learner has not been tested. After mature consideration I have come to the conclusion that tests should be made on young children in a school for the blind, and that the same facilities should be afforded them as for tactile reading. In the latter this period extends over a number of years, and fluency is only attained after long practice. While I am inclined to think that tactile reading will be more easily acquired than reading by means of the Optophone, it must be borne in mind that the literature available through the former is relatively small, but through the latter world-wide and unlimited."

This report, though very favourable to the Optophone, leaves the question of the maximum speed attainable undecided. The speed observed by Mr. Stainsby has already, within twelve months of the publication of his report, been exceeded more than tenfold, and I see no reason whatever why the speed of reading a page of print by ear should fall short of the speed obtainable by ordinary eye-reading. The only real handicap is in turning over the page, which involves removing the book and re-inserting it.

But I think we can say that the problem of blindness, as far as reading is concerned, is now definitely solved, at least as regards print and typescript.

In conclusion, I am able, through the kindness of the Gaumont Co.'s "Around the Town" Editor, to show you a film of the Optophone in action at the National Institute for the Blind. This film had the honour of being shown before their Majesties last year on the occasion of their visit to the Earl of Derby. The last scene shown is Miss Green reading a book by ear, copying it on her typewriter, and correcting her own typescript by reading it over in the Optophone—a performance which marks a distinct epoch in the history of achievement by the blind.

ANNUAL MEETING.

101st SESSION, 1921-22.

The Annual Meeting of the Shareholders and Members for the past session was held in the Museum, College Square North, on the 14th November, 1922.

Mr. Henry Riddell, M.E., M.I.Mech.E., President of the Society, occupied the chair, and among those present were:—Professor Gregg Wilson, O.B.E., M.A., D.Sc., Ph.D., M.R.I.A.; Councillor E. J. Elliott, Messrs. H. C. Lawlor, M.R.I.A.; J. M. Finnegan, B.A., B.Sc.; T. Edens Osborne, F.R.S.A.I.; Wm. Faren, F.R.S.A.I.; W. B. Burrowes, F.R.S.A.I.; J. G. Grogan, James Loughridge, A. Milligan, S. Turner, and P. J. M'Mullan, J.P. Apologies for absence were announced from Sir Charles Brett, LL.D.; Dr. S. W. Allworthy, M.A.; and R. M. Young, M.A., M.R.I.A.

The Chairman called upon the Hon. Secretary to read the report of the Council, which was as follows:—

The Council has pleasure in submitting its report on the work of the Society during the past session.

OBITUARY.

Unfortunately we have to record, with regret, the death of the following shareholders and members:—

Edward H. Clarke.
Sir Wm. Crawford, J.P.
F. Stanley Jones.
Henry Musgrave, O.B.E., D.L.
David C. Patterson.
John Sinclair, D.L.
John Workman, J.P.

MEMBERSHIP.

Your Council is glad to intimate that there has been a steady increase of Members under the new subscription scheme, thus justifying the step the Society took in creating a new class of membership in 1914. In that year there were only 182 Shareholders and Members. At the end of the session covered by this report there were over 300 Shareholders and Members.

During the present session your Council unanimously decided to elect the following gentlemen Hon. Members of the Society, making the list of these up to seven:—

Sir Charles Brett, LL.D.

Robert Magill Young, J.P., M.A., M.R.I.A., F.R.I.B.A.

Fournier d'Albe, D.Sc. (Lond. & Birm.), A.R.C.Sc. (Lond.), M.R.I.A.

LECTURES.

While the lectures have not been so numerous—only eleven as compared with sixteen in the previous year—yet all of them were important and much appreciated by the Members and their friends. On each occasion they were well attended. The session was opened on the 5th October, 1921, by Professor J. Arthur Thomson, M.A., LL.D., F.R.S.E., who delivered an instructive lecture entitled "The Conquest of Land and Air: a Study in Natural History," in the Assembly Minor Hall. On the 16th January last a special lecture was given in French by Professor Savory, M.A., to commemorate the tercentenary of the great French dramatist Molière. The second portion of the session was opened in the Assembly's Minor Hall by an interesting lecture on "Comets," delivered by the Rev. W. F. A. Ellison, M.A., of the Armagh Observatory; while our new Honorary Member, Dr. Fournier d'Albe, kindly gave a special address in the Physics Lecture Theatre at Queen's University on " The Optophone," an instrument which the lecturer had invented, and which enables totally blind people to read ordinary print.

A complete list of the lectures and lecturers appears on pages 114 and 115.

COUNCIL THANKS.

The Society is again indebted to the Vice-Chancellor of Queen's University (the Rt. Hon. the Rev. Thomas Hamilton, M.A., D.D., LL.D.) for the use of Lecture Theatres at the University for those lectures requiring experiments, and also to the Chairman (Alderman S. T. Mercier, J.P.) and Members of the Technical Instruction Committee for the use of rooms in the Municipal College of Technology.

The Council desires to express its sincere thanks for the facilities so willingly rendered, and for the co-operation existing between these Institutions and the Society.

The Council also wishes to thank the lecturers for their assistance, and the local Press for the continued interest it takes in the Society's meetings.

IRISH NATURALIST.

In order to assist the " Irish Naturalist," which is the organ of the various Natural History Societies in Ireland, and which, like many other scientific magazines, had suffered financially during the war, the Council felt that it was only right that we, as the senior Society in Belfast, should give a subscription and donation amounting to seven pounds. This has been duly acknowledged and much appreciated.

EXCHANGES.

Your Council continues to receive in exchange, from home and foreign societies, valuable publications which considerably augment the Society's Library. So important has become the Library and so inadequate is the space available for the additions that your Council gladly agreed to an application from the University authorities for the loan of a selection of pamphlets and publications. The University undertakes to permit access to the loan by Members of the Society and to return it when required.

ARMOUR PLATE.

The Steel Armour Plate which has formed such a striking object at the Museum entrance since 1889, on loan from his Majesty's Dockyard at Portsmouth, has now been presented to the Society by the Lords Commissioners of the Admiralty.

ARCHAEOLOGICAL SECTION.

A separate report will be submitted by the Hon. Secretary of the Archaeological Section (Mr. H. C. Lawlor, M.R.I.A.), at the Annual Meeting of the Sectional Members, which will be held during the month. This report will be printed in the proceedings. The Section deserves to be congratulated upon the amount of practical work it has been able to accomplish during the session.

HON. TREASURER'S STATEMENTS.

Our President (Mr. Henry Riddell, M.E., M.I.Mech.E.), who is also Hon. Treasurer of the Society, will submit the financial statement.

COUNCIL MEMBERS.

In accordance with the constitution of the Society five members require to be elected to the Council, in place of the following Members who retire by rotation, all of whom are eligible for re-election:—Sir Charles Brett, Dr. S. W. Allworthy, Messrs. Wm. Faren, T. Edens Osborne, and Arthur Deane.

HON. TREASURER'S STATEMENT.

The heaviest expenditure during the past year has been for printing and advertising. This is an outlay which the Society will feel is repaid by the interest taken in the proceedings circulated, and the effect on the numbers of our Members. It is expected that a considerable reduction will be found in the cost of this service for the coming year.

Attention is drawn to the fact that there is a good balance in the hands of the parent Society credited to the funds of the Archaeological Section. A detailed Statement of Accounts as passed by the Government Auditor appears on page 107.

ADOPTION OF REPORTS.

Professor Gregg Wilson, in moving the adoption of the report, which was cordially passed, congratulated the Society, and more particularly the Hon Secretary, on the satisfactory nature of the work done. He commented favourably on the grant to the "Irish Naturalist." It was the only magazine of the kind published in Ireland, and it would be a disgrace to the whole of them if it were allowed to die. Scientific publication was expensive and not properly appreciated. Mr. Lawlor and his colleagues of the Archaeological Section were to be sincerely congratulated on the brilliant and practical work they were doing.

Councillor Elliott, in seconding, said citizens and visitors alike had been greatly pleased by the lectures. He was only sorry that the grant to the "Irish Naturalist" could not be larger. The importance of the work by the Archaeological Section was indicated by references he had seen in American and Spanish journals.

ELECTION OF COUNCIL MEMBERS.

Sir Charles Brett, LL.D.; Dr. S. W. Allworthy, M.A., F.G.S.; Messrs. T. Edens Osborne, F.R.S.A.I.; Wm. Faren, F.R.S.A.I., and Arthur Deane were re-elected Members of the Council for three years, on the proposition of Mr. W. B. Burrowes, seconded by Mr. G. O'Searle, B.Sc.

VOTE OF THANKS.

Mr. H. C. Lawlor, M.R.I.A., moved a vote of thanks to Mr. Henry Riddell for his services during the past year as President of the Society, which was seconded by Mr. T. Edens Osborne, F.R.S.A.I.

Resolved—"That the Society desires to place on record their high appreciation of the services of the Hon. Secretary, Mr. Arthur Deane, during the past year, and hereby desire to convey to him their warmest thanks." Moved by H. C. Lawlor, seconded by Professor Gregg Wilson.

R. J. WELCH

General View of Church, Round Tower, and Inner Cashel, Nendrum.

ARCHAEOLOGICAL SECTION.

The sixth annual general meeting of the Archaelogical Section was held in the Old Museum on Monday, November 27th, at 4 p.m. The attendance of members was large.

Sir Charles Brett, LL.D., the Chairman, briefly referred to the increased interest that was being taken both by the members and the general public in the work of the Archaeological Section. The renovation and repair of the ruins of the ancient Celtic Monastery of Nendrum, on Mahee Island, had received wide notice in the Press, not only in the local papers and the "Irish Times," but in the principal English, Continental and American papers. This widespread interest augured well for the future prosperity of the Section.

Mr. Henry Riddell, President of the Society and Hon. Treasurer, submitted his Annual Report; as a special fund had been raised for the work at Nendrum he would deal with the general finances and this special fund separately. The actual money at credit of the ordinary account was £98 13s 7d. Subscriptions for the opening season, together with the subsidy from the parent Society, interest, etc., would amount to about £40, so that the section would have about £140 in hand. Of this, £100 had been voted towards the work at Nendrum, and would be transferred to that fund in due course. Dealing with the special fund, a sum of £387 8s 7d had been received in subscriptions (a list of the Subscribers appearing as an appendix, pp. 109-113); sale of tickets for the two excursions which had been organised amounted to £48 3s 4d, making the total receipts £435 11s 11d. The expenditure came to the following:—James Lowry, contractor, for labour and materials, £312 2s 0d; cost of excursions (train fares, chars-à-bancs, etc.), £38 15s 2d; advertisements, including publication of subscription lists, £27 17s 6d; travelling expenses, postages, photography, lantern slides and miscellaneous, £28 2s 11d; total—£406 7s 7d; leaving balance of £29 4s 4d, to which had to be added the £100 voted by the

Section, making a nett sum of £129 4s 4d in hand for completing the work at Nendrum, which it was hoped would be recommenced in the coming spring.

Mr. H. C. Lawlor, M.R.I.A., Hon. Secretary, presented his Annual Report of the past season's work. He said that the Executive Committee had held three meetings during the season, at which all the members, except one, attended regularly. They had also visited the work in progress at Mahee Island, in which all had taken the keenest interest. Six members of the Archaeological Section had resigned, but a large number of new members had been introduced, the total membership being now over 100. He then gave a detailed interim report on the work carried out at Mahee Island, which will be found on pages 92—106.

The following were elected as office-bearers for the coming season:—

Chairman: Sir Charles Brett, LL.D.

Hon. Treasurer: Mr. Henry Riddell, M.E., M.I.Mech.E., President of the Society.

Hon. Secretary: Mr. H. C. Lawlor, M.R.I.A.

Executive Committee: Mr. Arthur Deane, M.R.I.A. (ex officio), Canon Carmody, Messrs. W. B. Burrowes, T. E. Osborne, Godfrey Ferguson, C.E.; Fergus Greeves, J. Theodore Greeves, F. A. Heron, D.L.; and R. S. Lepper, M.A., F.R.Hist.S.

The Hon. Secretary, in conformity with notice duly given, explained that in his opinion the income of the Archaeological Section arising from subscriptions was not sufficient to enable the Section to carry out a programme of work commensurate with the importance of its objects, and moved "That the annual subscription to the Section be increased from 5/- to 10/-, commencing with the Session 1923-1924." As several members were strongly opposed to this, the motion was withdrawn.

The Hon. Secretary called attention to two further items on the agenda of which he had given formal notice as follows:—

To consider the advisability of abbreviating the name of "The Archaeological Section of the Belfast Natural History and Philosophical Society," and passing a recommendation to this effect to the Council of the Society; and

To consider the possibility of reviving either in its old form, or under some other name, "The Ulster Journal of Archaeology."

He said he thought there were strong reasons why the name of The Archaeological Section of the Belfast Natural History and Philosophical Society should be altered. In its present form it was exceedingly long and cumbersome; at the same time narrow. Its membership was practically confined to within a radius of a few miles of Belfast, and the reports of its proceedings had an exceedingly limited circulation. He would like to rope in all Ulster Archaeologists and raise the standard of the Section from that of a mere department of a purely local society to that of at least provincial standing. There are hundreds of archaeologists throughout Ulster, to say nothing of the rest of Ireland, who hardly ever more than hear of the Natural History Society, or know that it has an Archaeological Section, much less see the Annual Reports. He had no wish to break off or alter the present happy relations between the Section and the venerable Society of which it was a branch, and he though there was nothing to prevent it remaining affiliated with the Natural History Society while abbreviating the name to the "Ulster Archaeological Society," at the same time making a strong effort to bring in as many members interested in archaelogy all over Ulster as possible. If this could be carried out he thought in time the old Ulster Journal of Archaeology might be revived, either under its old name or some other. He formally moved the following resolution:

"That in the opinion of this meeting it is advisable to abbreviate the name of 'The Archaeological Section of the Belfast Natural History and Philosophical Society' to the 'Ulster Archaeological Society,' without altering in any way its existing relationship to the Parent Society."

Mr. Henry Riddell, President of the Society, strongly opposed the motion. He said that it was quite open to the Section to form itself into a new Society if it saw its way to do so, but that it could not be a Society or Association and still be a Section of the Natural History Society. It must either continue as it was or be an entirely separate, although friendly, entity. In that case he would go so far as to say that the Natural History Society would discontinue its financial contribution towards the funds of the Section if the proposed change were carried out.

Colonel Berry, M.R.I.A., expressed his sympathy with the idea the Hon. Secretary had in view, and wished to see the Archaeologists of Ulster, of whom there were very many, roped in to the Archaeological Section, so that its scope might be broadened and the interest in its work be widely extended; but he did not think that this end could be achieved by the means suggested by the Hon. Secretary. He did not see how an Ulster Archaeological Society or Association could be anything but a separate entity, and remain a section or branch of the Belfast Natural History and Philosophical Society.

Mr. W. B. Burrowes and Mr. T. E. Osborne also spoke to the same effect, and on the advice of the Chairman, Sir Charles Brett, the Hon. Secretary withdrew the motion.

On the question of the possibility of the revival, under its old name or some other, of the "Ulster Journal of Archaeology," Canon Carmody said that while in sympathy with the idea, he was afraid that there could not be got together material in Ulster to keep such a publication alive for more than a limited number of issues. If it could be guaranteed that sufficient original research work would be forthcoming to supply material for such a publication, he would support it as far as he could, but he would not advise a resuscitation of such a publication under the old name. The First Series of the " Ulster Journal of Archaeology " he said was conducted purely as such, but the Second Series gradually deteriorated, so far as archaeology was concerned, until it ceased to be an archaeological publication at all. He would let the old name rest, and if material were forthcoming for a new publication, let it be called " The Ulster Archaeologist," or " The Ulster Antiquary," but he was doubtful if material would be forthcoming.

Mr. R. J. Welch was strongly opposed to the word " Journal " appearing in any publication of the sort. He believed that an " Ulster Antiquarian Magazine," embracing archaeology, folklore, genealogy, heraldry, topography, and even geology, would appeal to thousands of readers in America and the Colonies if properly edited and advertised. He was in hearty support of some such publication being organised.

Sir Charles Brett, agreeing with Canon Carmody, doubted if there could be sufficient material of a purely archaeological nature forthcoming to sustain for any length of time a new archaeological publication, but suggested that a sub-committee be appointed consisting of Colonel Berry, Messrs. R. J. Welch, H. C. Lawlor, W. B. Burrowes, A. Deane, and himself, to consider the whole matter and report to the Executive Committee at a later date.

This suggestion was unanimously agreed to. Votes of thanks to the office-bearers brought the meeting to a close.

Interim Report on Work of Repair and Preservation of the Ruins of Nendrum Monastery, Mahee Island.

Mr. H. C. Lawlor, M.R.I.A., Hon. Secretary, explained that but for the scholarly researches of that famous archaeologist, the late Bishop Reeves, no one to-day would have known even of the existence of Nendrum. Just eighty years ago he undertook the work of editing that portion of the Taxation Roll of Pope Nicholas IV. which relates to the Dioceses of Down and Connor and Dromore, and every student of Irish Antiquity knows the value of that stupendous work, and the care and knowledge of his subject displayed in Reeves' *Ecclesiastical History of Down, Connor and Dromore*, a work which is the foundation of probably nine-tenths of all we know to-day of the early history of the Counties of Antrim and Down. That Taxation Roll is still preserved in London, and it is to be hoped that another Reeves will yet arise to edit the remainder of the Roll, which relates to the other Irish Dioceses.

Before Reeves' time the existence of Nendrum was completely unknown, to say nothing of its locality. Certain writers confused the references to it in ancient writings with Aendruim, or Antrim; others thought these references applied to a site on the Copeland Islands; it rested with Dr. Reeves to unravel the historical tangle made of the subject by previous writers. The result of his work is best seen in a pamphlet he read before the Down and Connor Architectural Society in 1845. This booklet is now exceedingly scarce, but has been, fortunately, reproduced in the Ulster Journal of Archaeology, 2nd Series, Vol. VIII., which is easily accessible.

When Dr. Reeves visited Nendrum in 1844 nothing resembling ecclesiastical remains were visible except the stump of what was locally regarded as an old lime kiln; it was in practically the same condition as it remained up to the time the recent repairs were carried out; all around were brambles and thorns, and no other building was then visible; but assuming the possibility of the supposed " old lime kiln " being the stump of a round tower, Reeves searched for remains of the associated church, which after some clearing of the overgrowth, he found. To confirm the conclusion he had thus come to, he spent some days clearing the debris away from the south wall and in excavating the site generally, finding several graves both inside and outside the remains of the building. He removed a number of skulls to Belfast for scientific examination. These skulls have now been discovered among those collected by Grattan, and are included in the Grattan collection in possession of our Society. A full scientific report on these skulls and others found in our excavation is in course of preparation by Professor Walmsley of the Queen's University.

As the present work on the repair and preservation of the ruins is as yet far from complete, the following can only be regarded as an interim report; we have found many valuable relics bearing on the history of the foundation, and have come to conclusions on many points. Some of these conclusions may, however, be modified or upset on further investigation, so that beyond a brief account of the work done during the summer recently ended, I deem it wiser to defer the publication of minute details or conclusions until our materials are more complete.

Early last spring Mr. A. G. Johnston, the owner of the Western end of the Island, on which the ruins stand, was approached on the subject of the suggested work, and nothing could exceed the kindness with which he has responded to our wishes and assisted us in every way from the beginning of and all through the progress of the work. I should like to refer also to the assistance of Major C. Blakiston Houston, whose bungalow is close by; his assistance was invaluable; ever on the spot, he noted down every day's work, marked on a map the spots where each relics was found, and recorded details of inestimable value. In Mr. James Lowry, the contractor, and his sons we were more than fortunate; they brought as well selected a body of workmen as it would be possible to procure; after a few days' instruction these men got used to examining every spadeful of soil; every fragment of pottery or metal, every scrap of stone carved or chipped by hand, no matter how small, was carefully put aside, and the position of its discovery reported.

The actual work commenced early in June with the removal of the clumps of briar and thorn which almost completely covered the site. These had to be torn out by the roots by means of chains drawn by horses. By the 12th of June a good clearance had thus been made inside the inner cashel, ready for actual excavation. While clearing work proceeded on the site of the inner cashel wall and outside it, ten good labouring men commended removing the debris from the sites of the church and round tower. Fortunately, Canon Carmody was able to superintend this work for the first fortnight while the guest of Major Houston, and under his experienced guidance the men soon learned to proceed with the minute care necessary for such work.

Soon the shape of the church became clear. The stones as removed from the debris heap were all carefully examined and put to one side. The vegetable soil which had accumulated in the debris was examined carefully as extracted before being carted away and spread over adjoining fields. Here again the spreaders examined it as spread. On the occurrence of the first shower of rain after spreading, the soil was again gone over with rakes so that nothing might be missed. Many small objects of interest that might easily have been lost were thus recovered, including several mediaeval coins, worked flint flakes, an iron spear ferrule and stone beads or buttons. Among the raised heaps of the debris of the church were discovered evidences of burials, including many of young children, probably unbaptised infants, which up to a

Ab ut 1/3rd ac ual size. A. E. Lawlo .

Fragment of old Norse (?) Inscription.

couple of centuries ago, or in places, recent times, were buried in some otherwise disused holy place.

Of the larger relics found on the church site the most important was a triangular fragment, 10½ins. across, of an inscribed grave stone containing a portion of a circle, beneath which are remains of two lines of inscription. By extending the arc of the circle it can be ascertained that the width of the stone was originally about 27ins. The men were offered a special reward if they could find any more fragments of the inscription, but, unfortunately, although most careful search was made, nothing more of it was found except a few inches of the circle.

The inscription on this stone is shown. Copies of this were sent to the British Museum, and by the authorities there to Cambridge University; to the National Museum in Dublin; to the National Museum, Copenhagen, and elsewhere. No quite satisfactory solution is as yet forthcoming. Several letters are ordinary Irish characters of about the 10th century, three are runes of about the same period, while four are difficult to classify. I am not without hope that even yet we may find more of this inscription, so that meantime it may be premature to print a very ingenious but purely tentative solution offered by Professor R. A. S. Macalister, of the National University in Dublin. He considers it probable that the stone is a fragment of a grave slab to a Norse Abbot of Nendrum, of tenth or eleventh century. The abbot's name is missing, but the remains of the first line may perhaps be read BRIMOBATA, interpreted as equivalent to PRIMABOTA, the old Norse for "of the chief abbot." The fourth letter occurs in some later runes found in the North of England, and is clearly M. The fifth letter is the same as the small letter between the two lines, and seems undoubtedly to be an O or long A. The sixth letter is clearly a B, but the seventh presents some difficulty; it resembles the fifth with the lower cross stroke incomplete. This is probably a differentiation between the two, denoting the slight difference in the letters O and A. The eighth letter as it stands is a runic L, but it has been found, as in the Killaloe rune, used as a T. The last letter is a runic A (short). The small letter between the lines seems to be a correction in the bottom line, a letter omitted in carving and inserted afterwards. Unfortunately so little of this line is left that no one has been able to decipher it. The third letter from the right cannot be identified as belonging to any known alphabet.

Professor Macalister regards this inscription as of immense archaeological importance. It is one more monument, like his Killaloe find, of the Christianisation of the Norseman, and even indicates an instance of what was probably a rare occurence—a Norseman actually entering into Irish monastic life and becoming abbot.

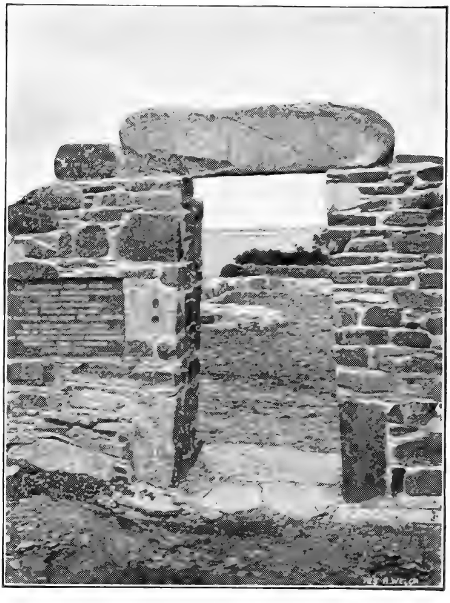
About the middle of July the sites of the church and ground about the round tower were cleared, and all the finds put carefully to one side.

The excavation had laid bare all that was left of the church, which proved to be the remains of apparently a mediaeval nave, with a somewhat later chancel of the same width, with a small exedra or sacristy on the north side. The inside measurements of the whole, above the foundation or plinth, are 52 by 16 feet.

At the west end were remains of butresses, continuations of its north and south walls. These protruded 30ins. x 30ins. The jambs of the west door were completely gone, but the huge lintel, measuring 66ins. x 18ins. x 15ins., was lying prone on the door step.

From July onwards the men worked steadily clearing away the debris from the inner and second cashel walls, replacing the fallen stones as they proceeded. A number of men were engaged at this work until October, when we stopped work for the winter, while others were turning over the soil over the greater part of the space enclosed by the inner cashel. While removing the debris of the inner cashel

Inner Cashel showing Monks' Pathway.



West Doorway restored, showing Commemorative Tablet.

R. J. WELCH, PHOTO

wall a remarkable pathway or paved causeway was found leading from the southern entrance round inside the wall and turning towards the west door of the church. This is apparently the pathway "by which the brethren come to Matins," referred to in Colgan's "Actae Sanctorum," of which O'Laverty gives a translation in his Down and Connor (Vol. I., 354). This refers to the period when Saint Colman of Dromore was a boy at Nendrum under Saint Mochaoi, probably between 465 and 470, when he is related to have performed a miracle in removing a large stone which impeded the brethren on their way to church. This story is preserved in the name of a little bay in Ranish or Rainey Island, almost within a stone throw of Mahee Island, known from time immemorial as Colman's bay. This paved causeway is a most important discovery. It leads from the west door of the church to where is now one of the three entrances in the inner cashel wall. Had it not been for the pathway stopping at this point, the antiquity of this entrance could not have been established. No remains of the original jambs of this entrance remain, but from the pathway beginning at this entrance we can establish not only the fact of an entrance having been here originally, but the strong presumption that it led from the hospitia or dwellings of the monks, and guest houses, which must in consequence have occupied the wide space between the south sections of the inner and second cashels. This flat space has been subjected to tillage, so that all signs of these huts, which undoubtedly were of wattle and mud or planks, have long since disappeared.

Among the more important discoveries made during the turning over of the soil were foundation walls of apparently very ancient buildings of dry masonry, directly East of the church. These suggest a building of considerable size joined on to the inner side of the cashel wall; but, unfortunately, little of it can now be traced, as probably the builders of the mediaeval church of stone and lime used the old materials to build the new church. The site is now largely taken up with graves covered with rough stones. As these graves are in rows it is difficult to say in all cases whether the rows of stones are remains of the ancient building or rows of stone-covered graves. Further investigation on this point may enable us to arrive at a more definite conclusion.

To the West, just inside the second cashel wall or stone faced terrace are foundations of two very ancient buildings of dry masonry. Our examination of these is not yet complete. In the Western portion of this second cashel was found, in a fairly complete state a wide doorway about 5ft. 6ins. across, inside which are the foundations of what may be two janitors' cells, in such a position that if restored, they would divide the wide entrance into three narrow ones, by which ingress or egress could only be effected in single file.

To the North-East and North of the second cashel there can be traced among the bracken and brambles foundations of numerous walls and apparently circular buildings, but these have not as yet been touched. If during the coming season we are enabled to excavate and repair these, doubtless much of great interest may be exposed to view.

To the South of the church, about half-way between it and the inner cashel wall, were two circular mounds or rings about 20 feet in diameter. These were carefully excavated, and proved to be the remains of two promiscuous heaps of bodies. The skeletons included those of men, women, and children, thrown together without any arrangement or order, and lightly covered with soil and stones. On digging lower we came upon older regular graves lined with rough stones. These graves were not due E. and W., but with the feet to the S.E. In two places among these graves were fragments of foundations of a stone and mortar building, but so small as to afford no clue as to what the building could have been; yet, that the traces of building distinctly showed lime mortar is of great importance, as the skeletons of the promiscuous heap were superimposed on the masonry fragments, proving that these bodies were thrown in the heaps at a comparatively late date, and after the introduction into Ireland of

Section of Second Cashel Wall, West Side showing entrance, before and after restoration.

R. J. WELCH. PHOTO.

lime mortar in building. This is generally admitted to be about the ninth century at the earliest.

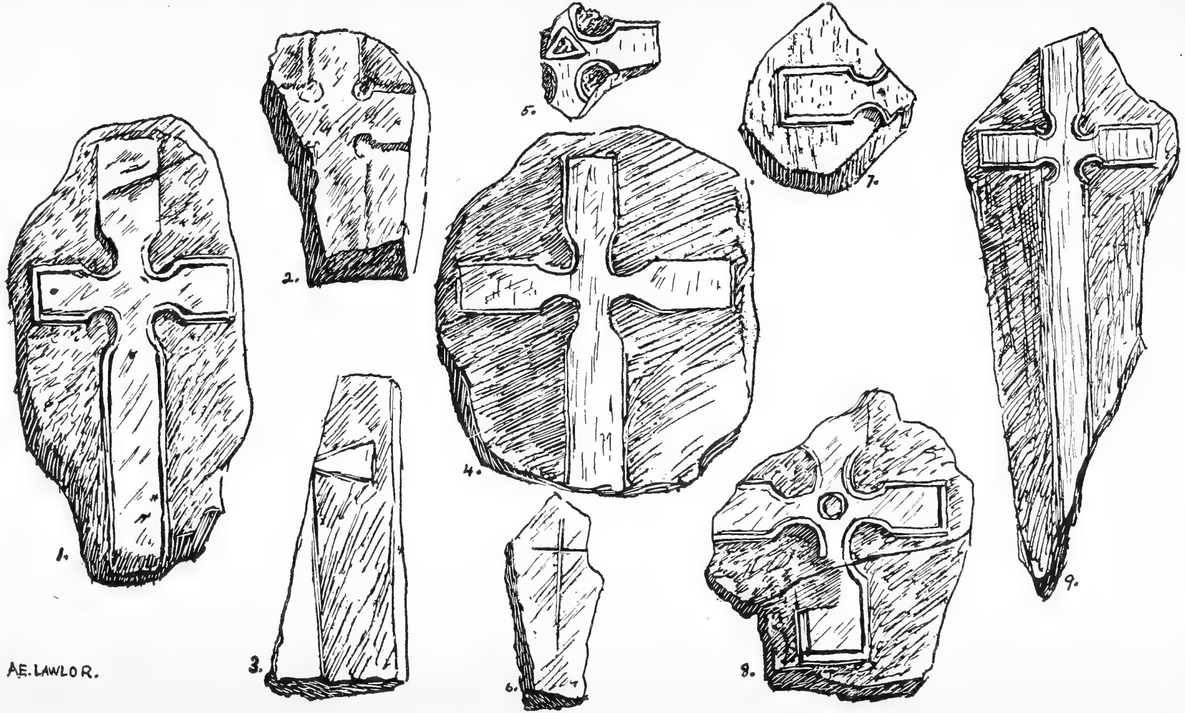
Two causes can be alternatively put forward to explain these heaps of skeletons—namely, a plague, or a battle or massacre. Two facts, however, seem to rule out the former of these two alternatives. Among the skeletons was one of a woman apparently holding in her arms a child of a few years old. Had they both died of a plague and been brought here for interment this could not have been. The second fact is that one of the skulls was that of a man who had met his death by sword cut. We may eliminate, therefore, a plague, as the explanation of these heaps of skeletons, and there remains the other alternative, a massacre or battle. Of the date of this there seems to be no clue to guide us, unless Professor Walmsley's examination of the bones gives one. There is little doubt that a massacre occurred at Nendrum in 974 when Abbot Sedna O'Deman "was burned in his own house," after which the annals never again mention Nendrum.

Of the stone lined graves which lay on a lower level than the mounds, these were close together, and extend over a considerable area South and East of the mounds. It seems as if this were at an early date the burial place for the people of the surrounding country, and not confined to the inmates of the monastery, as remains of both sexes were found side by side. From near the South-West corner of the church to almost the southern entrance to the inner cashel can be seen in the grass what appears to be the foundation of an ancient wall, which probably shut off the burial place from the level space bounded on the west by the paved pathway. This open space probably corresponded with what, in later monasteries, was known as the cloister garth.

To the west of the church, on clearing away a considerable quantity of debris we found a number of stone topped graves. These are all much shorter than human adults, and investigation showed that the stone tops were only surface markings of full length graves, not stone lined, some 18 to 24 inches deep. Most of these graves appear to have been disturbed at some time, as the bones in many cases were in confusion. In every case care was taken to leave the grave covers exactly as when exposed.

About 30 feet from the west gable, and among these graves was a small mound. Examination of this produced a fragment of a carved cross (No. 5) and one small stone about 9ins. x 6ins. with a rude scratched cross on one surface (No. 6). On penetrating further into this site a roughly-shaped rectangular foundation of what may have been a mud and wattle cell was exposed. From its position it was probably the cell of the janitor or ostiarius, an officer corresponding to the modern sexton or bell-ringer. The janitor was in Holy Orders, and in monastic rank was probably the lowest. Excavating to some depth under the floor of this rectangular space we came upon several skeletons of men in position undisturbed. With one of these, a few inches from where were the finger bones, was a small polished stone celt, almost an exact duplicate of one of the three found together in our investigation in the Rath of Dreen (See Report B.N.H. & P. Society for 1919).

In clearing away debris in various places many carved stones of great interest were found in addition to the one already referred to. These were mostly crosses of a very early Celtic type (illustrated). In no single instance had any of these crosses a nimbus, nor was any one inscribed with lettering. Most of these were found in the neighbourhood of the west gable; but few were perfect, and where fractured the pieces when found were widely scattered. For instance, one arm of cross No. 8 was found in the debris of the east end of the church, while the other portion was among the debris of the inner cashel. A stone cresset lamp mould and a rough sandstone fragment of a slab cross were also found in other parts of the cashel wall. The finding of these three carved stones is exceedingly puzzling in an effort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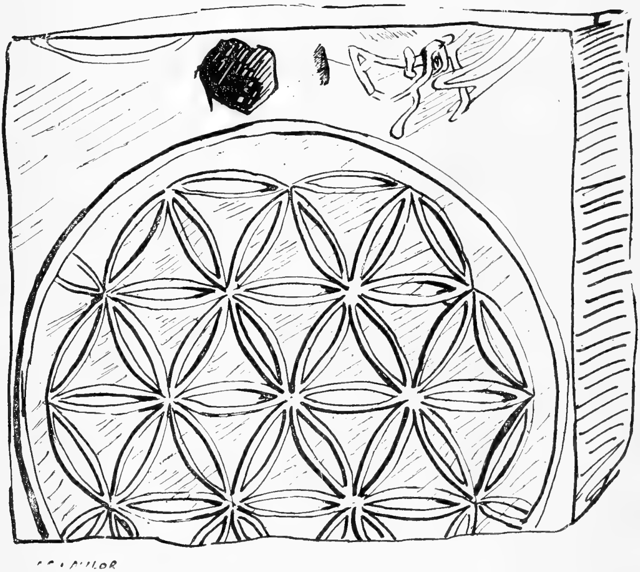
A.E. LAWLOR.



Fragment of Pillar Stone, with Romanesque Geometrical Design; exactly similar designs occur at Clonmacnoise, Lough Derg, and Isle of Man.

to arrive at the age of this cashel. They were among the stones which had tumbled from the cashel, as if they had been at one time built into it, which would imply a quite late date for the erection; but we have no proof what they were, and they may have been merely thrown where they were found and got covered up by the gradual falling of the stones from the wall. The two crosses Nos. 4 and 1 were found outside the N.W. and S.W. corners of the church respectively on clearing away the debris. The cross figured No. 9 cannot now be found. Fortunately, the late Mr. W. H. Patterson made an accurate sketch of it about the year 1874. It was then built into a fence near Mr. Johnston's house; but, unfortunately, Mr. Patterson omitted to record its size, so that in the accompanying sketch it cannot be included in the scale given. To the South of the West gable were found the square base and face of a remarkable sundial. Five small fragments of the pillar of this were found in various places, all richly carved in local whinstone. In a fence built of stones taken from various places, in modern times, was a large cubic fragment of a pillar stone, measuring 12ins. x 11½ins. x 8ins., on which is incised an elaborate geometrical design of interlaced circles. In spite of careful search, no other fragment of this pillar stone has been found. In the debris of the church itself were found three window-top arches, each carved out of one piece of sandstone. These show that the windows were, as is usual in the early churches, very narrow but widely splayed inside.

The question of how best to conserve all these relics was one which gave rise to much careful consideration. The first impulse was to remove them to the Society's collection in the Belfast City Museum, but the proprietor, Mr. Johnston, strongly expressed his desire that they should not be removed from their natural home and ancient associations.

The restoration to its ancient position of the great lintel stone of the west door was also an important problem, as, although the door step remained, the doorway was entirely gone. Mr. R. J. Welch came to our assistance with his invaluable store of photographs of Irish church doorways, and it was eventually decided to restore the west doorway after the model of that of the Church of Tomgraney, Co. Clare, whose west gable with protruding butresses apparently coincides exactly with what remained of the west gable of Nendrum. Tomgraney is regarded as being one of the very oldest, if not the oldest, example remaining of lime mortar built churches in Ireland, and dates from the 10th century. From the width of the lintel at Nendrum, 66 inches, we gauged the width of the top of the doorway to have been the middle half, 33 inches, the outside fourths, 16½ inches each, resting on the jambs. After the model of Tomgraney and many other ancient churches, it was decided to widen the doorway slightly at the bottom, to 38 inches, or an inward slope from doorstep to lintel of 2½ inches in each jamb in a height of 70 inches. To conserve the ancient crosses and other carved stones, it was decided to insert these in slight recesses in a partially-restored gable, at each side of the doorway so constructed, and lest anyone should in time to come make the mistake of thinking that these stones are in their original position, or that this fragment of the west gable is wholly original, a tablet to the following effect has been inserted in the wall:

The Ecclesiastical Ruins of Nendrum
on Mahee Island and the Encircling Cashel Walls
Have Been Repaired
by the Belfast Natural History
and Philosophical Society
by Permission of the Owner, Mr. A. G. Johnston.
The Carved and Inscribed Stones,
Found in Various Places in the Debris
are Inserted in This Partially Restored Gable
Merely for Their Conservation.
23rd June, 1922.

It is, perhaps, needless to say that the above inscription contains an apparent inaccuracy, as manifestly all could not have been done that is stated to have been done on the 23rd of June. The date is the festal date of Saint Mochaoi, the patron saint of Nendrum, whose death is recorded in the ancient festologies as having taken place on that day in 497. fourteen and a quarter centuries ago.

The date is important as, according to supposed ancient usage, a church dedicated to a patron saint was orientated in accordance with the ascension of the sun on the festal date of the saint. The Church of Nendrum lies almost exactly W.S.W. by E.N.E. If anyone could observe sunrise on the 23rd of June, and compare it with the position of the church, allowing for the alteration of the actual position arising from the progress of the universe, it would be interesting.

The round tower stump was cleared of ivy early in June, and the fallen debris cleared from around its base. It was found that the ivy had obtained such a hold of the ruin that almost the entire outer surface of the masonry above the first three or four feet had been pushed down. At the height of five and seven feet, respectively, however, there remained still in original position two through stones, from which the batter of the wall could be accurately ascertained. This was very slight, only about one inch in seven feet. The wall itself is mounted on a plinth about three feet in height. The actual external circumference of the plinth is 47 feet, and above the plinth 45ft. 6ins. Comparing these measurements with those of other round towers, supplied by Petrie, it may, with fair accuracy, be assumed that the original height of the tower, that is if it were ever actually finished, was between 50 and 60 feet.

The condition of the ruin was, before we repaired it, not much altered from Reeves' time. In his pamphlet, already referred to, he reproduced a careful sketch of it, showing the position of the two protruding "through stones." This sketch, unfortunately, has not been reproduced in the Ulster

Journal (2nd Series), already mentioned, but may be seen in O'Hanlon's Lives of the Irish Saints (23rd June). The Ulster Journal, however, supplies an admirable sketch of the tower (in 1902) by Mr. Joseph Carey, and a plan and section by Mr. Philip Reynolds. From perusal of these three sketches it will be seen that the ruin appears to stand upon a small grass knoll. This on investigation proved to consist merely of the fallen masonry of the tower, pushed down in the course of time by the ivy. The men were set to remove this knoll, which was from three to four feet high, laying aside all the fallen stones, and removing the vegetable soil. The fallen stones were restored to the ruins, all being set in good cement, the ivy having been carefully extracted and the roots killed with strong chemical solution. The inner shell of the stump of the tower remained intact, and it was found that when the mason had restored all the fallen stones of the outer surface they only sufficed to bring it to the existing height of the inner shell. The broken top of the building has now been grouted with cement so that no water can lodge, or consequently, vegetation find a place to root.

If our estimate of the original size of the tower is correct, what remains is about one-fifth. The question arises, what then became of the missing four-fifths? The builders of the Elizabethan Castle at the Causeway could not have quarried here for their material, as they had copious supplies of stone on the shore and in the outer cashels, much nearer at hand, which they used, but by no means exhausted. The only other apparent use the material of the tower could have been put to was to build the church close at hand; but it is almost inconceivable that the builders of the church would pull down the tower to build the church had it been still standing at the time. A probable solution of the difficulty may be found in the following:—The date of the erection of the tower originally may, with all likelihood, be fixed shortly after the first invasion by the Danes, say about the year 850, when it likely would have been erected as a place of refuge, watch tower, and also bell tower. It likely shared in the general destruction by the Danes, which appears to have taken place in 974, when the abbot Sedna "was burned in his house."

Adamnan, in his Life of Saint Columba, tells us that the hospitium, tugurium or domus abbatis, the abbot's residence, was a detached building usually on an eminence, from which the abbot could survey the surrounding monastery. It is, therefore, quite possible that the abbot Sedna used the tower as his house, and that its destruction is, therefore, implied in the entry in the annals saying that he was burned in his own house in 974. The thoroughness displayed by the Danes in their destruction of everything Christian on their early expeditions is well-known, and seems to find confirmation at Nendrum by the minuteness of the fragments into which all the crosses (except two) and the sundial were smashed. We may therefore conclude with reasonable certainty that the round tower was knocked down by them, and lay a hopeless ruin a century or so later, when the church of stone and lime-mortar was built. If this were the case, as seems most likely, it would have been only natural that the church builders used the debris of the tower to build their church. At the same time they naturally used any loose stones that remained over to repair the cashel wall. This would satisfactorily account for the three carved fragments already referred to having at one time been built into it.

In many places large quantities of pottery of various ages were found, also iron implements, sharpening and polished stones or rubbers, broken querns, and other miscellaneae.

Before giving details or theories regarding these I am consulting, or have already consulted some of the best authorities. Meantime I await more complete reports.

I have not referred to the known history of Nendrum. A useful outline of this has been supplied by Bishop Reeves. Much, however, has developed since his time, and further facts are gradually coming to light. I am therefore deferring a report on this subject until enquiries now pending are more complete.

It is regrettable that, owing to the narrowness of the road from Comber to Mahee, and the extraordinary number of dangerous corners, several more or less serious motor accidents occurred to the cars of visitors during the season. Fortunately no one was injured. It is to the credit of the neighbouring farmers and local residents that these danger spots on the road are in process of being removed. The worst of the corners are being cut off and the road widened where necessary. To effect this the farmers concerned gave up stretches of their land, either for nothing, or for a nominal charge. The Down County Council are assisting in every way. The road from the Ardill Memorial Causeway to Mr. Johnston's gate is his private property. He has most generously offered to surrender this road to the County Council if they will render it more convenient for motor traffic. He has also offered the necessary ground at the end of the road for making a turning place for motor cars. All this is costing a considerable sum of money, and it is to the credit of all concerned that most of the money necessary has been locally subscribed, though more is still required. The Executive Committee voted a subscription of £10 towards this laudable object. The special thanks of the public are due to Mr. David Boyd, of Comber, who has been primarily responsible for organising this most important undertaking, and to Mr. James G. Wilkin, C.E., County Surveyor, for his assistance in carrying it out. The Down County Council have generously recognised their responsibilities as part custodians of this most important National Monument, and have already supplied the sum necessary for the repair of the Elizabethan castle at the causeway.

I have to thank Dr. A. E. Lawlor for the admirable etchings accompanying this report. Her view of the nine ridges from which the Island derives its name of Nendrum is taken from a point in Island Reagh (not illustrated). The photographs are by Mr. R. J. Welch, M.R.I.A.

EDUCATIONAL ENDOWMENTS (IRELAND) ACT, 1885.

The Account of Belfast Natural History and Philosophical Society for the year ended 30th June, 1922.

Dr. — **Cr.**

CHARGE.

	£	s.	d.
To Subscriptions	£219	19	0
,, Dividends	28	1	8
,, Rents	150	0	0
Balance against Account on June 30th, 1922	20	17	0
Total,	£418	17	8

LIST OF SECURITIES.

	£	s.	d.
4½ per cent. Debentures, York Street Spinning Co.	£400	0	0
5 per cent. 1929-47 War Loan	305	5	3

DISCHARGE.

	£	s.	d.	£	s.	d.
By Balance as per last Account				£52	15	7
,, Maintenance of Premises, etc.,				8	12	9
,, Rent, Rates and Taxes				43	16	3
,, Salaries, etc.				38	17	0
,, Other Payments, viz.:—(b)						
Printing and Stationery	£169	4	0			
Advertising	39	5	3			
Postage, etc.	21	14	0			
Lantern Slides for Lectures	8	19	0			
Lecturer's Expenses	5	17	0			
Archaeological Secy. Expenses	2	13	9			
Legal Expenses	2	2	0			
Exploration at Mahee	20	0	0			
Bank Interest, Charges, and Ck. Book	5	1	1			
				274	16	1
Total,				£418	17	8

We certify that the above is a true Account.

ROBERT M. YOUNG, Governor.
HENRY RIDDELL, Accounting Officer.
10th day of August, 1922.

I certify that the foregoing Account is correct.

G. BRYAN, Auditor.
3rd day of October, 1922.

IN ACCOUNT WITH THE BELFAST NATURAL HISTORY AND PHILOSOPHICAL SOCIETY.

1921—1922.

Dr. **ARCHAEOLOGICAL SECTION.** Cr.

Date	EXPENDITURE.	£	s.	d.
June 30, 1922	—Collection of Subs. and Postages ...	£0	4	0
	Share of Audit Fee	0	4	0
	H. C. Lawlor, Travelling Exps.	1	19	0
	,, Postages ...	0	14	9
	Printing, *re* Knowles Colln. ...	6	6	0
	,, Proceedings etc. ...	3	19	3
	,, Mound of Downpatrick	0	17	6
	Wrappers, Rubber Stamp, etc. ...	0	9	3
	Rent of Room for Meetings ...	1	0	0
	Mahee Fund (James Lowry) ...	20	0	0
	Balance in hands	142	1	7
		177	15	4

Date	REVENUE.	£	s.	d.
June 30, 1921	—Balance in hands	£70	11	4
June 30, 1922	—Subscriptions	24	6	0
	Subsidy from B N. H. & P. Socy.	16	10	0
	Interest ,, ,,	3	0	0
	Mahee Fund Special	63	8	0
		177	15	4

SUBSCRIPTIONS TO MAHEE FUND.

	£	s.	d.
Acheson, F. W.	1	0	0
Aird, W.	2	0	0
Andrews, Miss Elizabeth	1	11	6
Andrews, Ernest	1	0	0
Andrews, the Rt. Hon. J. M.	1	0	0
Andrews, J.	0	10	0
Andrews, Oscar	1	0	0
Andrews, Mrs. T. J.	0	10	0
Atkinson, Arthur S.	1	0	0
Baird, Major	5	0	0
Bèbe, Charles	1	0	0
Bell, Mrs.	5	0	0
Belfast Naturalist's Field Club	3	16	9
Bennett, S. A.	0	10	0
Berry, Colonel	1	0	0
Breakey, Rev. J. P.	0	10	0
Blakiston-Houston, Major C.	1	1	0
The Ven. Archdeacon Brett	0	10	0
Brett, Sir Charles	5	0	0
Bristow, Jas. R.	1	0	0
J. B. Bryson	1	0	0
Boal, R.	1	1	0
Boyd, David	1	0	0
Boyd, Hugh	0	10	6
Byrne, J. Edward	1	1	0
Burrowes, W. B.	4	2	0
Campbell, A. A.	0	10	6
Campbell, James	1	0	0
Carmody, Rev. Canon	1	0	0

	£	s.	d.
Chambers, R.	0	5	0
"Christian, An Early"	0	10	0
Christen, Madame	0	5	0
Clark, George E.	5	0	0
Clark, Sir George	5	0	0
Cleland, A. McI.	1	0	0
Cleland, W. M.	1	0	0
Cleaver, J. F.	1	1	0
Cleaver, Colonel	1	0	0
Combe, George	1	0	0
Corbett, J.	1	0	0
Craig, H. C.	2	0	0
Craig, Captain E. S.	1	1	0
Crawford, Rt. Hon. Col. Sharman	1	0	0
Crawford, Hugh	0	3	0
Cunningham, Josias, Jun.	6	0	0
Deacon, Miss E. A.	1	0	0
Deane, Arthur	1	0	0
Despard, V. D.	1	0	0
Diamond, Rev. Edward, C.C.	1	0	0
Dobbs, Miss M. E.	5	0	0
Down and Connor and Dromore, Rt. Rev. Bishop of	2	2	0
Down Co. Council (for Castle)	15	0	0
Edwards, —	0	2	0
"E. F."	0	5	0
Ewart, G. Herbert	3	0	0
Faren, W.	0	10	0
"Friend, A" (1)	0	10	0
"Friend, A" (2)	1	10	0
"Friend, A" (3) Anon.	1	0	0
"Friend, An Interested"	25	0	0

	£	s.	d.
"Friends, A Few at St. Malachy's"	2	2	0
Ferguson, Godfrey W.	1	0	0
Finlay, A. H.	2	2	0
Greeves, Arthur	1	0	0
Greeves, Fergus	1	0	0
Greeves, Joseph	1	0	0
Greeves, Leopold	1	0	0
Greeves, J. Theodore	1	0	0
Haddow, C. P.	1	0	0
Hamilton, Rt. Hon. and Rev. T. R.	1	1	0
Hastings, Messrs. S. & T.	1	1	0
Henderson, Sir Trevor	1	1	0
Herdman, A. T.	2	0	0
Herdman, R. E.	1	0	0
Heron, Francis A.	10	5	0
Higinbotham, Granby	1	0	0
Hunter, James	1	0	0
Hutchinson, Captain S. J.	1	0	0
Johnston, S. A.	2	0	0
Kernohan, J. W.	0	10	0
"Laisren"	1	0	0
Lawlor, H. C.	1	0	0
Lepper, R. S.	25	0	0
Londonderry, The Marquis of	2	2	0
Lowry, David E.	1	1	0
Mackie, James	2	0	0
MacKisack, Dr. H. L.	1	0	0
Magowan, T. R.	0	10	0
Malcolmson, Herbert	1	1	0

	£	s.	d.
Malcolmson, Major G. E.	1	0	0
Macoun, S. M.	1	0	0
Metcalfe, Arthur	2	2	0
" Methodist, A Primitive "	1	0	0
Mitchell, Captain W. C.	5	5	0
Montgomery, Miss E. S.	0	10	0
Montgomery, H. C. & T. W.	2	2	0
Murland, Captain C. W.	1	0	0
McAuley, Rev. T. H., C.C.	1	0	0
McCready, H. L.	1	0	0
McIlveen, J. H.	1	1	0
McKee, J. (Brooklyn, U.S.A.)	5	0	0
McKinley, Very Rev. Canon, P.P.	2	0	0
McLorie, James	1	1	0
McNeill, Miss and Mr. Wm.	2	0	0
Neill, H. J.	3	3	0
Orr, Dr. Gawn	1	1	0
Osborne, T. Edens	2	2	0
Parkes, Mrs. and Miss	0	10	0
Perceval, R. D.	0	10	0
Reade, J. S.	1	0	0
Richardson, Miss	2	2	0
Riddell, Alexr.	0	10	6
Riddell, Henry	1	0	0
" R "	0	2	6
Roden, Countess of	1	0	0
Rogers, W. E.	1	1	0
Rotary Club Excursion	5	15	6

		£	s.	d.
Sawers, T.	... ...	1	0	0
Sheil, Henry Percy	... ...	5	0	0
Shields, Rev. J., P.P.	... ...	1	0	0
Shillington, T. C.	... ...	2	0	0
Sides, W. S.	... ...	1	1	0
Sinclair, John	... ...	1	0	0
Sinclair, H. D.	... ...	0	10	0
Sinclair, Mrs. S.	... ...	1	0	0
Sinton, Alfred H.	... ...	5	5	0
Sinton, Edwin	... ...	1	0	0
Smith, Canon N. E. & Mrs.	... ...	0	10	0
Stevenson, John	... ...	0	10	0
Strick, G. H. O.	... ...	1	1	0
Toal, Rev. D. O. R., C.C.	... ...	1	0	0
Thompson, Joseph	... ...	1	1	0
Turner, S.	... ...	0	10	6
Turtle, W. H.	... ...	1	0	0
"Ulster, For the Credit of"	... ...	100	0	0
Wallace, Rt. Hon. Colonel	... ...	2	0	0
Wallace, William	... ...	0	10	0
Welch, R. J.	... ...	1	1	0
"Well Wisher"	... ...	1	0	0
Williams, Captain	... ...	1	0	0
Wilson, George	... ...	1	1	0
Young, R. M.	... ...	1	0	0
Contents of Collecting Box at Nendrum ...	...	10	5	4
		£387	8	7

LIST OF LECTURES

1921-1922.

1921.

5th October. *In Assembly Minor Hall.*
"The Conquest of Land and Air: A Study in Natural History," by Prof. J. Arthur Thomson, M.A., LL.D., F.R.S.E.

8th November. *In Municipal College of Technology.*
"The Public Appreciation of Art," by Mr. Ivor Beaumont, A.R.C.A.(Lond.), M.S.A., F.R.S.A., F.I.B.D.

29th November. *In Municipal College of Technology.*
"Recent Investigations on the Fuel Problem," by Professor H. Wren, M.A., D.Sc., Ph.D.

13th December. *In Museum, College Square North.*
"Ulster Philosophers," by Professor John Laird, M.A.

1922.

10th January. *In Assembly Minor Hall.*
"Comets," by Rev. W. F. A. Ellison, M.A.

16th January. *In Museum, College Square North.*
"Molière," by Professor Savory, M.A.

31st January.	*In Museum, College Square North.* "The Use of Phosphates in Agriculture," by Mr. G. S. Robertson, D.Sc.
7th February.	*In Museum, College Square North.* "Some Products of Wood Waste," by Mr. W. H. Gibson, O.B.E., D.Sc., F.I.C., F.Inst.P.
24th February.	*In Queen's University.* "More About the Erectness of Plants," by Professor James Small, D.Sc., Ph.C., F.L.S., M.R.I.A.
7th March.	*In Queen's University.* "The Optophone: An Instrument for Reading by Ear," by Mr. Fournier d'Albe, D.Sc., A.R.C.Sc.(Lond.), M.R.I.A.
14th March.	*In Museum, College Square North.* "Drennan and His Times," by Mr. Alexander Riddell.

EXCHANGES.

ANN ARBOR—Publications of the University of Michigan.

BASEL (Switzerland)—Verhandlungen der Naturforchenden Gesellschaft in Basel, 1920-21.

BERGEN (Norway)—Publications of the Bergen Museum.

BUENOS AIRES—Anales del Museo Nacional del Historia Natural.

CAMBRIDGE (U.S.A.)—Bulletins and Annual Report of the Cambridge Museum of Comparative Zoology.

CAMBRIDGE—Proceedings of the Cambridge Philosophical Society.

COLORADO SPRINGS—Publications of the Colorado College.

DUBLIN—Proceedings of the Royal Dublin Society.

EDINBURGH—Proceedings of the Royal Society of Edinburgh, 1918-19.

,, Transactions and Proceedings of the Botanical Society, Edinburgh.

ESSEX—The Essex Naturalist. Vol. XX., Part 1.

GLASGOW—Proceedings of the Royal Philosophical Society, 1918-1920.

HALIFAX—Proceedings and Transactions of the Nova Scotian Institute of Science, 1918-19.

INDIANA—Proceedings of the Indiana Society of Sciences 1919-1920.

LA PLATA (Argentine)—Obras Completas y Correspondencia Cientificia de Florentino Ameghino.

LAWRENCE—Bulletins of the University of Kansas.

LIMA (Peru)—Boletin del Cuerpo de le Ingenieros de Minas del Peru.

LONDON—Quarterly Journal of the Royal Microscopical Society.

,, Memoirs of the Royal Astronomical Society.

,, Quarterly Journal of the Geological Society.

Lousanne—Bulletin de la Societe Vaudoise des Sciences Naturelles.

Madison—Bulletins of the Wisconsin Geological and Natural History Survey.

Madras—Report of the Government Museum of Madras, 1920-21.

Manchester—Journal of the Manchester Geographical Society, 1920.

Melbourne—Proceedings of the Royal Society of Victoria.

Mexico—Anales del Instituto Geologico de Mexico.

Milwaukee—Annual Report of the Milwaukee Public Museum.

New Haven—Transactions of the Connecticut Academy of Arts and Sciences, 1921.

Nictheroy—Achivos de escola Superior de Agricultura e Medica Veterinaria, 1921.

Ohio—The Ohio Journal of Science.

Orono—Bulletin of the Maine Agricultural Experiment Station.

Ottawa—Publications of the Geological Survey of Canada, Department of Mines.

Paris—Publications of the Geological Society of France.

Philadelphia—Proceedings of the Academy of Natural Sciences of Philadelphia.

,, Proceedings of the American Philosophical Society.

Portland (u.s.a.)—Proceedings of the Portland Society of Natural History, 1919.

Pusa—Reports of the Agricultural Research Institute, 1920-21.

Rennes—Bulletin de la Societe Geologique.

Rio de Janeiro—Report of the National Museum of Brazil.

Rochester (n.y.)—Proceedings of the Rochester Academy of Science.

SAN FRANCISCO—Proceedings of the Californian Academy of Sciences.

STIRLING—Transactions of the Stirling Natural History and Archaeological Society, 1920-21.

ST. LOUIS—Public Library Monthly Bulletin.

TORONTO—Transactions of the Royal Canadian Institute.

VIENNA—Verhandlungen der Geologischen Staatsanstalt, 1920.

WASHINGTON—Annual Report of the Smithsonian Institution.

,, Annual Report of the United States National Museum.

,, Publications of the Bureau of American Ethnology.

,, Bulletins of the Smithsonian Institution.

,, Contributions from the United States National Herbarium.

,, Proceedings of the United States National Museum.

,, Smithsonian Institution, Miscellaneous Collections.

,, Publications of the United States Geological Survey.

ZURICH (Switzerland)—Vierteljahrsschrift der Naturforchenden Gesellschaft in Zurich.

ZAGREB (Youngoslavie)—Glasnik Hrvaksko prirodoslovnoga Drustva, 1921.

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